

Foreword

This booklet is part of a complete service manual. Read the foreword in the service manual.



Always read the booklet Safety before proceeding.



A series of 20 horizontal dotted lines spanning the width of the page, providing a guide for handwriting practice.

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GENERAL

03 SPECIFICATIONS

030 General

Tightening torque, cylinder head

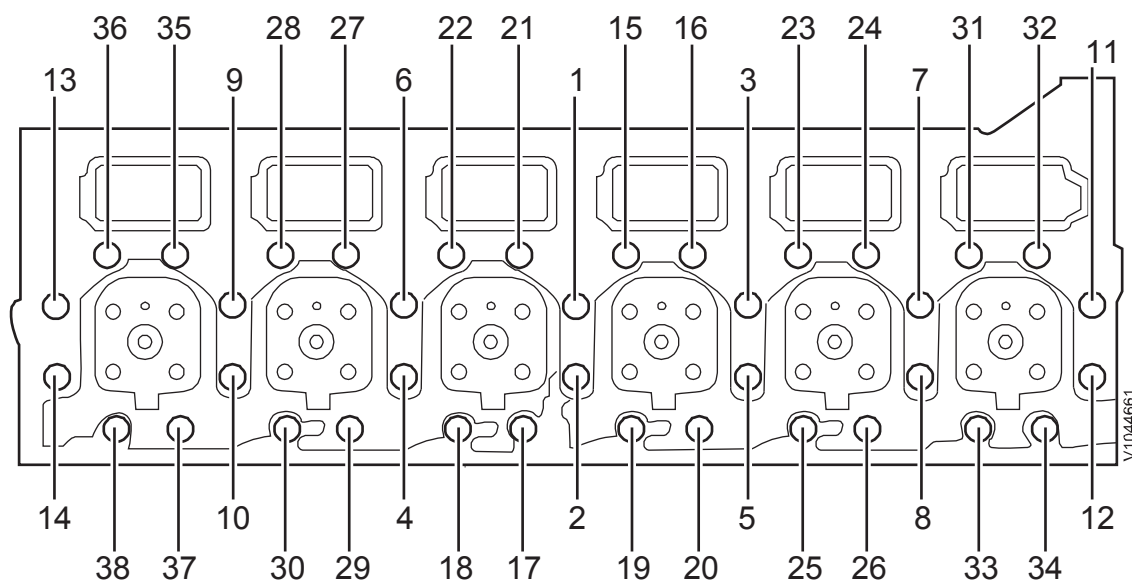


Fig.1 Cylinder head, D13

NOTE!

Tighten the bolts in the sequence shown in the figure.

Step 1	100±5Nm(74±3.7 lbf ft)
Step 2	120±5° Angle-tightening
Step 3	90±5° Angle-tightening

Engine, specification

General

	D13 F
Number of cylinders	6
Cylinder bore	131 mm (5.16 in)
Stroke	158 mm (6.22 in)
Displacement	12.78 litres (3.38 US gal)
Injection order	1-5-3-6-2-4
Compression ratio	18, 5:1
Low idle	
EXC	13.33 r/s (800 rpm)
WLO	11.67 r/s (700 rpm)
High idle	
EXC	28.33 r/s (1700 rpm)
WLO	31.67 r/s (1,900 rpm)
Max. full load rpm	
EXC	31.67 r/s (1,900 rpm)
WLO	35 r/s (2,100 rpm)
Weight, engine	
EXC	1,330 kg (3,042 lbs)
WLO	1,330 kg (3,042 lbs)
Total length	
EXC	1 585 mm (62.4 in)
WLO	1460 mm (57.5 in)

	D13 F
Width EXC WLO	789 mm (31.1 in) 1077 mm (42.4 in)
Height EXC WLO	1 250 mm (49.2 in) 1 215 mm (47.8 in)

Cylinder block, specifications

Length	1 052 mm (41.42 in)
Height, upper block face-crankshaft centre	422 mm (16.6 in)
Height, lower block face-crankshaft centre	120 mm (4.72 in)

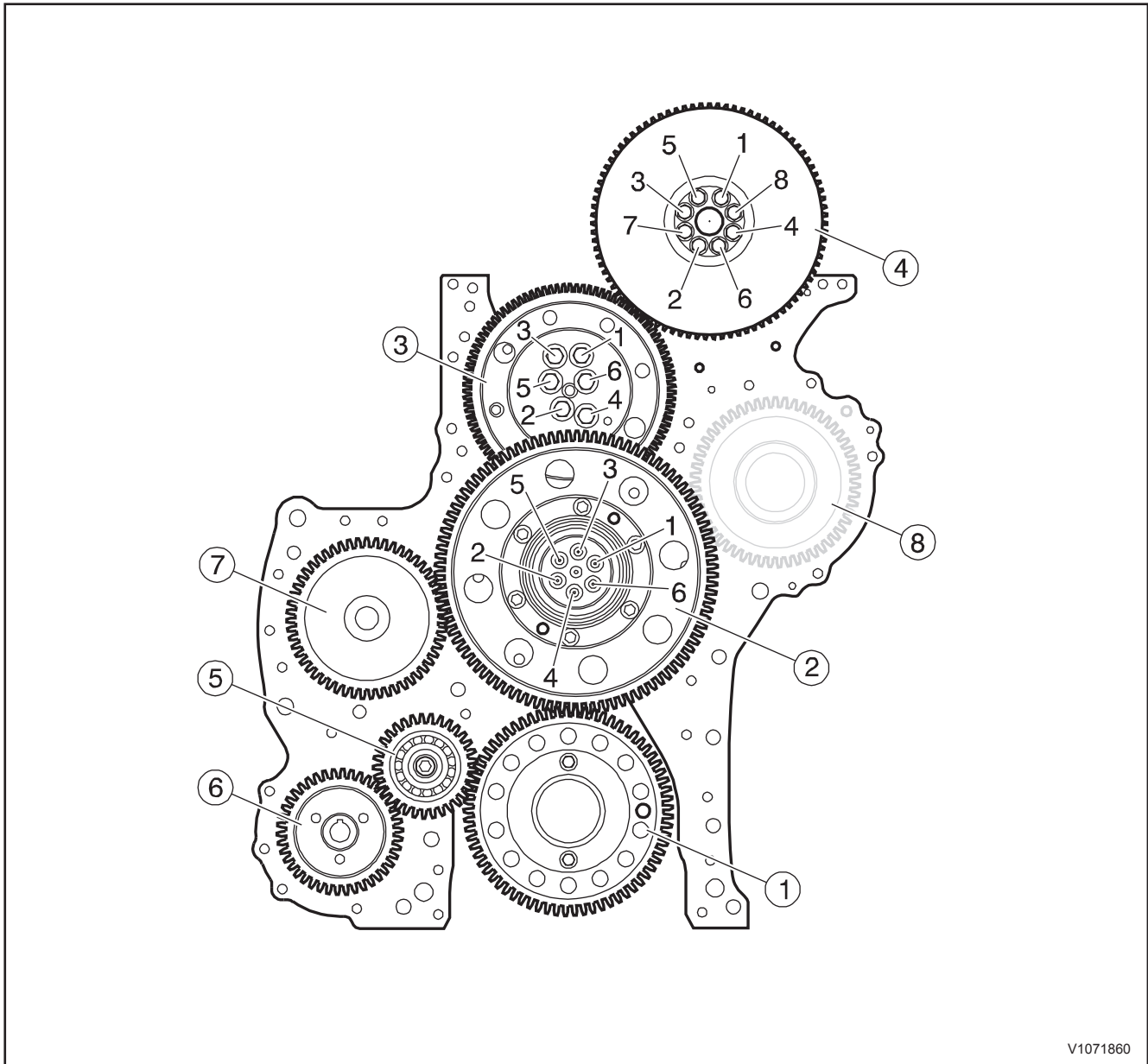
Cylinder liners	
Type	Wet, replaceable
Sealing surface's height over cylinder block's face	0.15 – 0.21 mm (0.0059 — 0.0083 in)
Number of seal rings per cylinder liner	3

Engine transmission, tightening torque

Tightening torques

NOTE!

Tighten in the order shown in the figure.



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Fig.2

Gears:	Tightening torque:
1. Drive gear, crankshaft	24±4 Nm (18±3 lbf ft)
2. Transfer gear, outer gear:	
step 1:	25±3 Nm (18.4±2.2 lbf ft)
step 2:	angle-tightening 110±5°
3. Transfer gear, adjustable:	
step 1:	35±4 Nm (25.8±2.95 lbf ft)
step 2:	angle-tightening 120° ±5°
4. Gear, camshaft: Vibration damper's 8.8-bolts may not be reused.	
temporarily:	10 Nm (7.5 lbf ft)
step 1:	45±5 Nm (33±4 lbf ft)
step 2: Angle-tightening	90° ±5°
5. Transfer gear	140±10 Nm (103±7.4 lbf ft)
6. Drive gear, lubrication oil pump for power take-off and fuel feed pump	100±10 Nm (74±7.4 lbf ft)

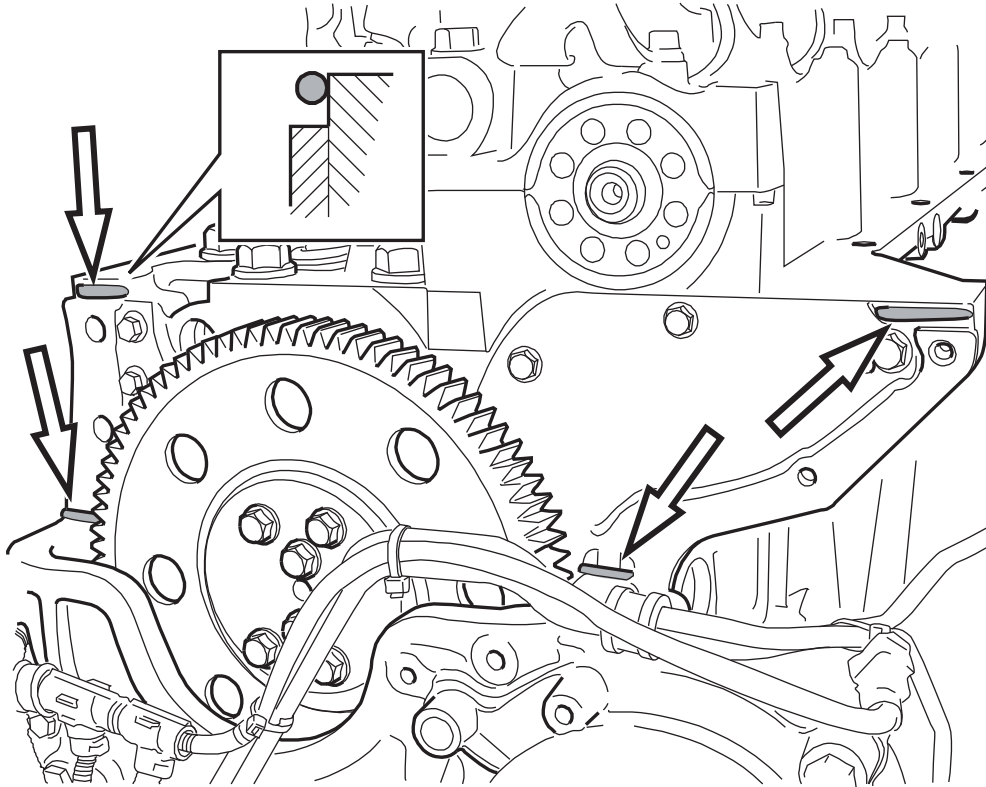
7. Drive gear, compressor	200+50/-0 Nm (148+37/-0 lbf ft)
8. Not used	

Timing gear casing

Apply a 2 mm (0.08 in) thick bead of sealant (part no. 11713514) as shown in the figures on the timing gear casing's contact face against the cylinder head. Install the rubber seals.

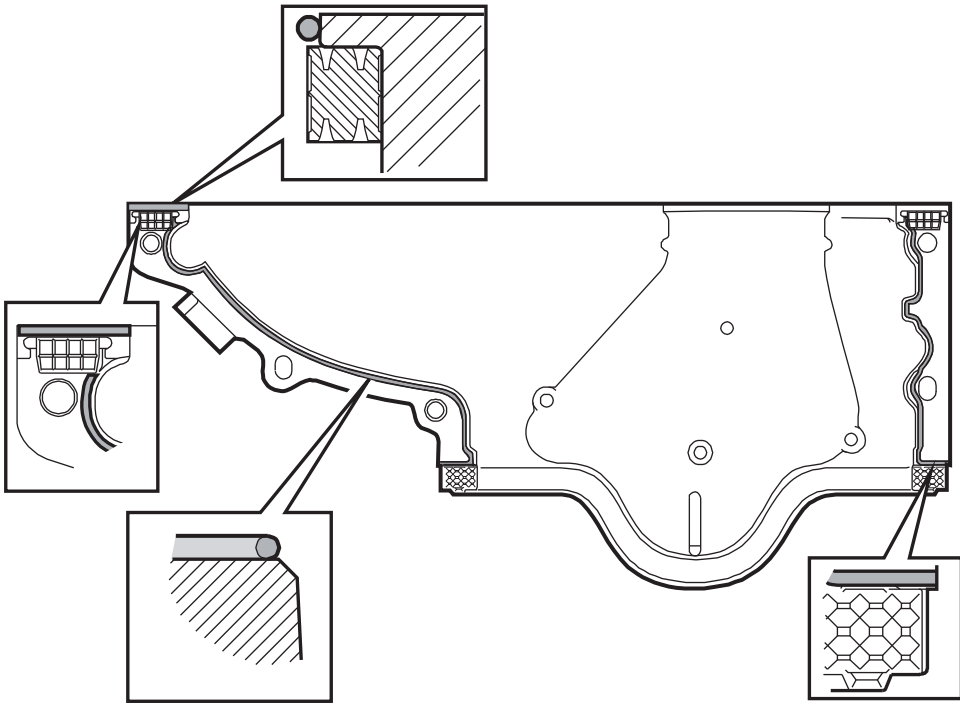
NOTE!

The timing gear casing must be installed and torque-tightened within 20 minutes of applying the sealant.



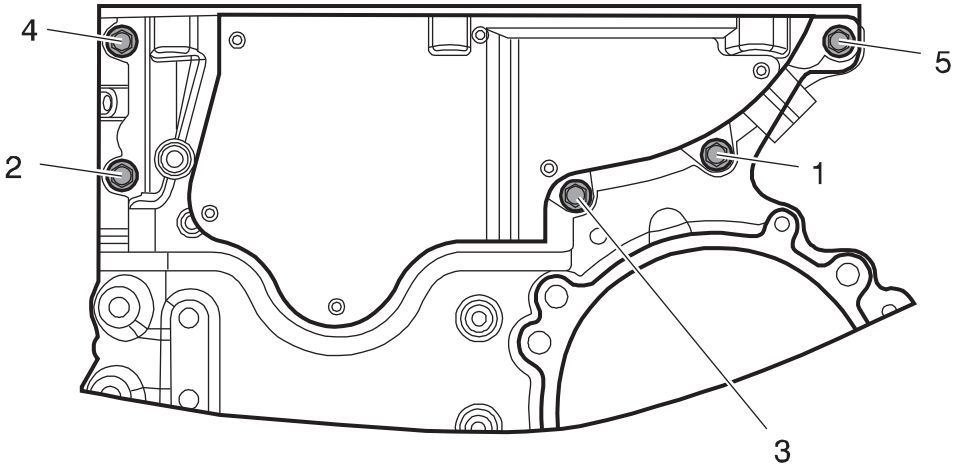
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Fig.3



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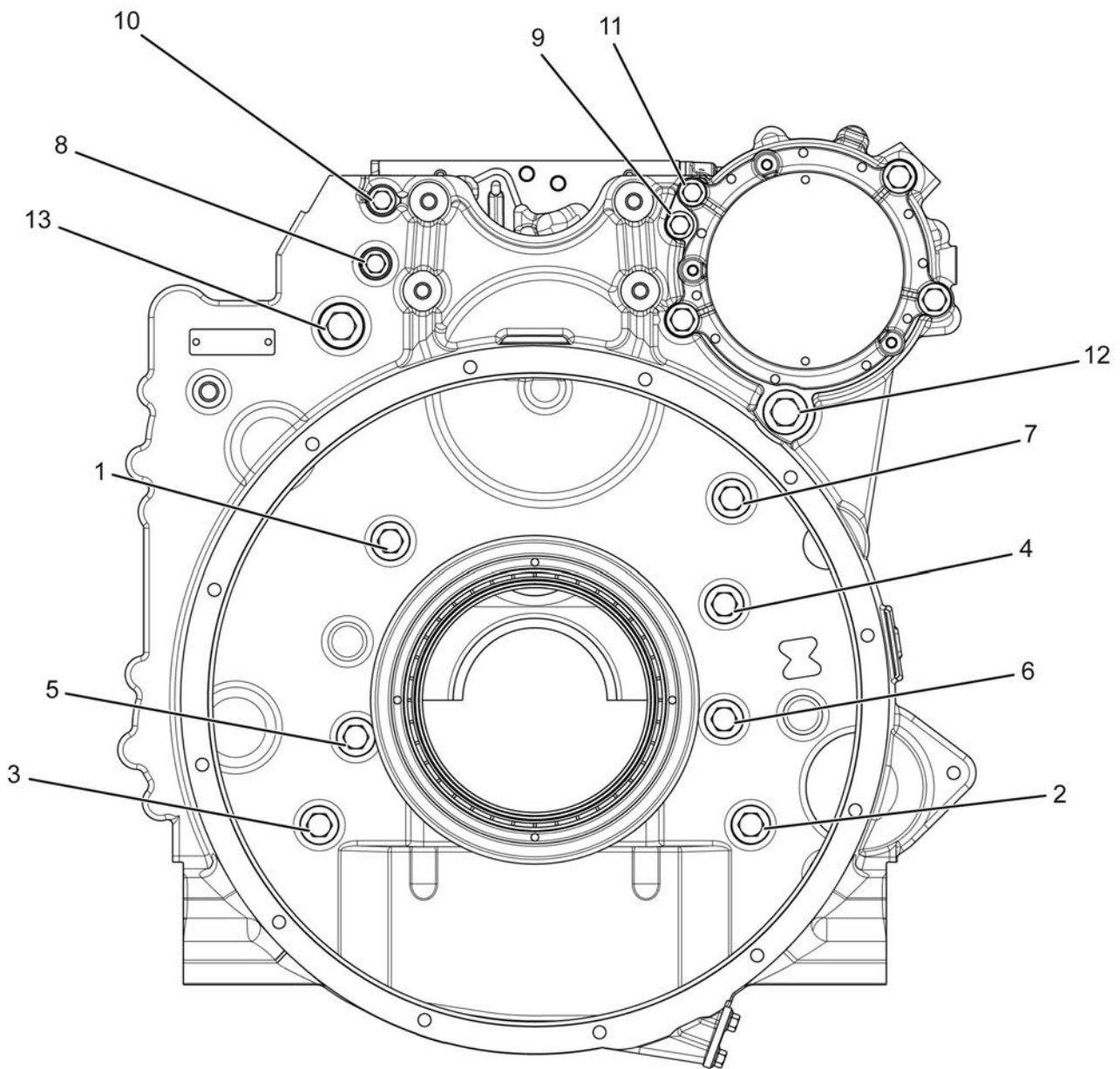
Fig.4



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Fig.5 Tightening torques, upper timing gear casing

Timing gear casing (upper)	
Step 1: Fasten the casing with the bolts 1 and 2.	4±1 Nm (3±0.74 lbf ft)
Tighten the bolts in the order shown in the above figure.	24±4 Nm (18±3 lbf ft)



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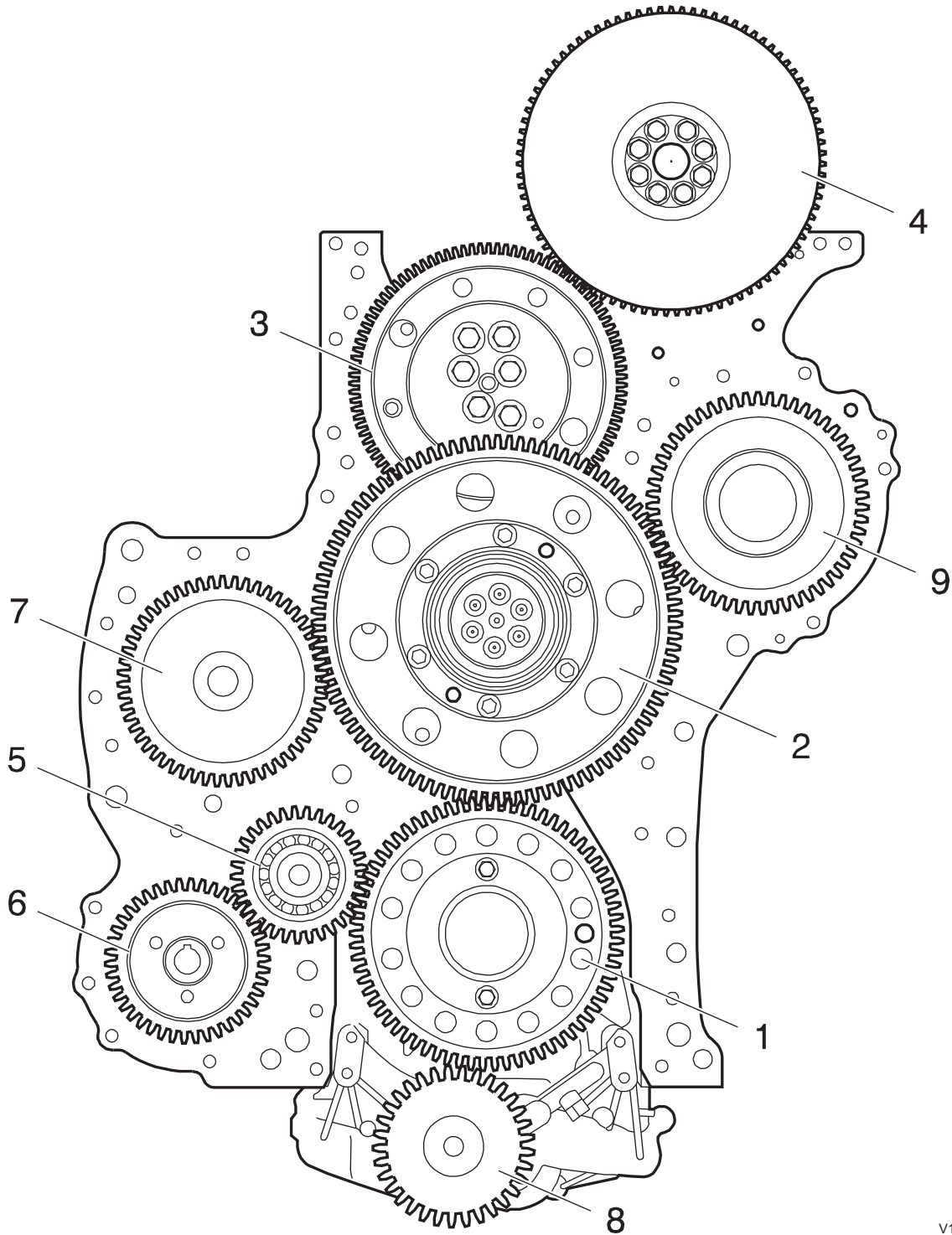
Fig.6 Flywheel housing, WLO/EXC

M14-bolts	160 ± 10 Nm (118 ± 7.4 lbf ft)
M10-bolts	48 ± 8 Nm (35.4 ± 5.9 lbf ft)
M16-bolts	100±5 Nm (74±3.7 lbf ft)

Tightening torques, timing gear plate

M8-bolts	28±4 Nm (21±3 lbf ft)
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Engine transmission, specification



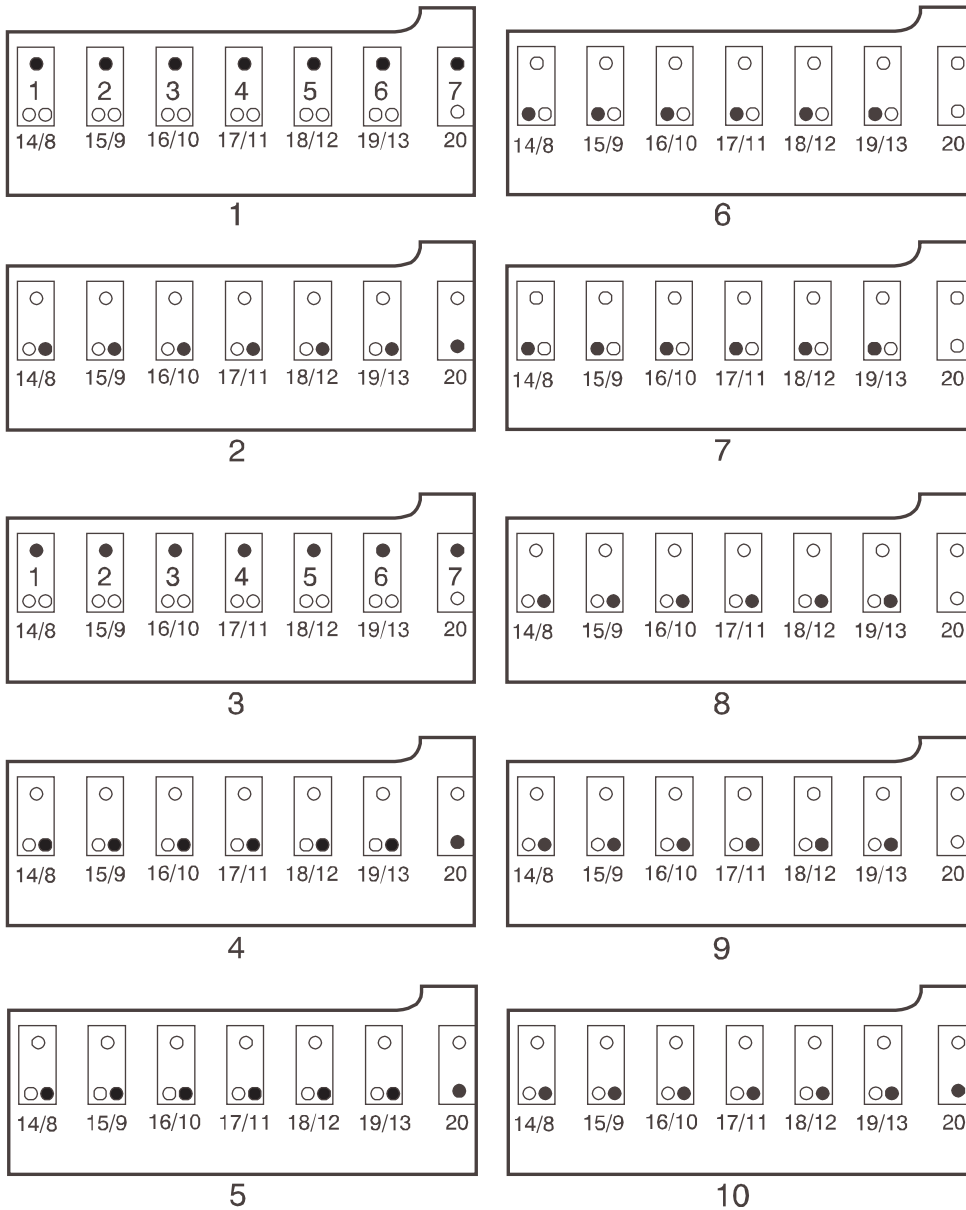
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Fig.7

Gears:
1. Drive gear, crankshaft
2. Transfer gears: outer and inner gear
3. Transfer gear (adjustable)
4. Drive gear and vibration damper, camshaft
5. Transfer gear
6. Drive gear, lubrication oil pump for fuel feed pump
7. Drive gear, compressor

8. Drive gear, lubrication oil pump	
9. Not used	
Gear flank clearance (backlash), adjustable transfer gear to camshaft's drive gear	0.05–0.15 mm (0.0019–0.0059 in)
Gear flank clearance (backlash), oil pump's drive gear	0.05–0.41 mm (0.0019–0.016 in)
Gear flank clearance (backlash), other drive gears	0.05–0.20 mm (0.0019–0.0078 in)
For checking camshaft installation:	
Valve lift, inlet valve, cylinder 1 at 6° after TDC	1.6 ± 0.3 mm (0.063 ± 0.012 in)

Rocker arm shaft, tightening torques



V1082177

Fig.8

Camshaft: (camshaft and bearing caps in place)	
Fit a mandrel to the number 7 bearing bracket to protect the guide sleeve.	
Step 1: Tighten screws 1–7	25±3 Nm (18±2.2 lbf ft)
Step 2: (with shorter additional screws) Tighten screws 8–13 and 20..... 60±5 Nm	60±5 Nm (44±3.7 lbf ft)
Step 3: Angle tighten screws 1-7	90°±5°
Step 4: Remove the extra screws 8–13 and 20	
Remove the mandrel from the number 7 bearing bracket.	

Rocker arm shaft: (Rocker arm shaft in place)	
Step 5: Tighten screws 8 - 13 and 20 in steps in the order 11, 10, 12, 9, 13, 8, 20.	60±5 Nm (44±3.7 lbf ft)
Step 6: Tighten screws 14–19	25±3 Nm (18±2.2 lbf ft)
Step 7: Angle tighten screws 14-19	120°±5°
Step 8: Untighten bolts 8–13	
Step 9: Tighten screws 8-13	25±3 Nm (18±2.2 lbf ft)
Step 10: Angle tighten bolts 8 – 13 and 20	120°±5°

Valve mechanism, specifications

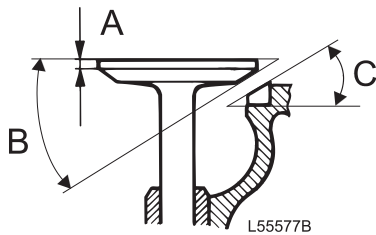


Fig.9

- 1 Valve disc, thickness (A)
- 2 Valve's seat angle (B)
- 3 Valve seat's angle (C)

Valves	
Valve arrangement	Top valves
Valve disc, diameter	
Inlet	42 mm (1.65 in)
Exhaust	40 mm (1.57 in)
Valve stem, diameter	
Inlet	7.968 mm (0.3137 in)
Exhaust	7.955 mm (0.3131 in)
Valve's seat angle	
Inlet	24.5°
Exhaust	39.5°
Seat's angle in cylinder head	
Inlet	25°
Exhaust	40°
Valve disc, thickness	
Inlet	2.766 mm (0.108 in)
Exhaust	2.163 mm (0.085 in)

Valve clearance, cold engine	
Inlet valves, checking value	0.15 — 0.25 mm (0.0059 — 0.0098 in)
Inlet valves, setting value	0.20 mm (0.0079 in)
Exhaust valves, checking value	0.75 — 0.85 mm (0.029 — 0.033 in)
Exhaust valves, setting value	0.8 mm (0.031 in)
Brake rocker arm, checking value	2.78 – 2.92 mm (0.109 – 0.114 in)
Brake rocker arm, setting value	2.85 mm (0.112 in)
Checking value without feeler gauge on valve yoke	Min. 3.20 mm (0.126 in)
Distance between valve disc and cylinder head's face: Inlet	Max. 1.85 mm (0.072 in) Min. 1.0 mm (0.039 in)
Exhaust	Max. 2.2 mm (0.086 in) Min. 1.4 mm (0.055 in)

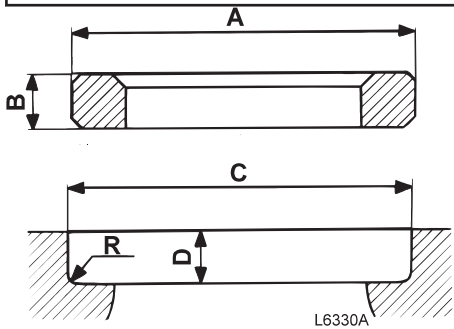


Fig.10 Valve seat and valve seat's position

Valve seats	
Outside diameter (A) standard: Inlet Exhaust	$\varnothing 45 (+0.065+0.081)$ mm (1.78 in) $\varnothing 43 (+0.07+0.086)$ mm (1.70 in)
Height (B): Inlet Exhaust	7.1 ± 0.04 mm (0.279 ± 0.0016 in) 7.25 ± 0.025 mm (0.285 ± 0.001 in)

Valve seat position	
Diameter (C) standard: Inlet Exhaust	$\varnothing 45 H7 (0/+0.025)$ mm (1.77 in) $\varnothing 43 H7 (0/+0.025)$ mm (1.69 in)
Depth (D): Inlet Exhaust	11.8 ± 0.13 mm (0.46 ± 0.005 in) 11.2 ± 0.13 mm (0.44 ± 0.005 in)
Seat's bottom radius (R): Inlet/exhaust	max. 0.8 mm (0.031 in)

Valve guides	
Diameter: Inlet/exhaust	$\varnothing 8 (0/+0.015)$ mm (0.31 in)
Height above cylinder head's spring face: Inlet/exhaust	24.5 ± 0.2 mm (0.96 ± 0.008 in)
Wear value	
Clearance, valve stem - guide Inlet/exhaust	max. 0.7 mm (0.028 in)

Valve spring	
Inlet	
Length, unloaded	73.8 mm (2.90 in)
Exhaust	
Outer valve spring: Length, unloaded	73.8 mm (2.90 in)

Valve mechanism, tightening torques

Tightening torques	
Lock nut, inlet valves	38 ± 4 Nm (28 ± 2.9 lbf ft)
Lock nut, floating valve bridge (exhaust)	38 ± 4 Nm (28 ± 2.9 lbf ft)
Lock nut, brake rocker arm	38 ± 4 Nm (28 ± 2.9 lbf ft)
Spring plate (tab)	25±3 Nm (18.5± 2.2 lbf ft)

Tightening torques, valve cover

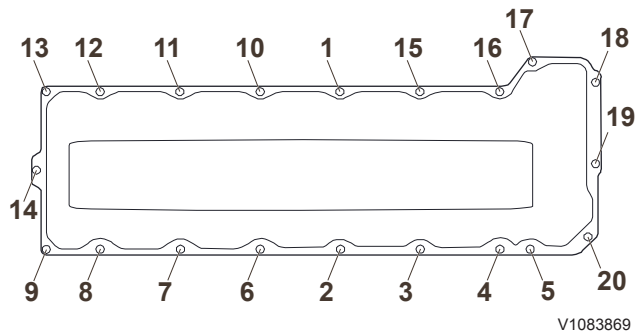


Fig.11 Figure 1 Tightening diagram, valve cover

Valve cover	
Valve cover, screws	25 ± 3 Nm (18 ± 2 lbf ft)

Oil sump, tightening torque

Oil sump, tightening diagram

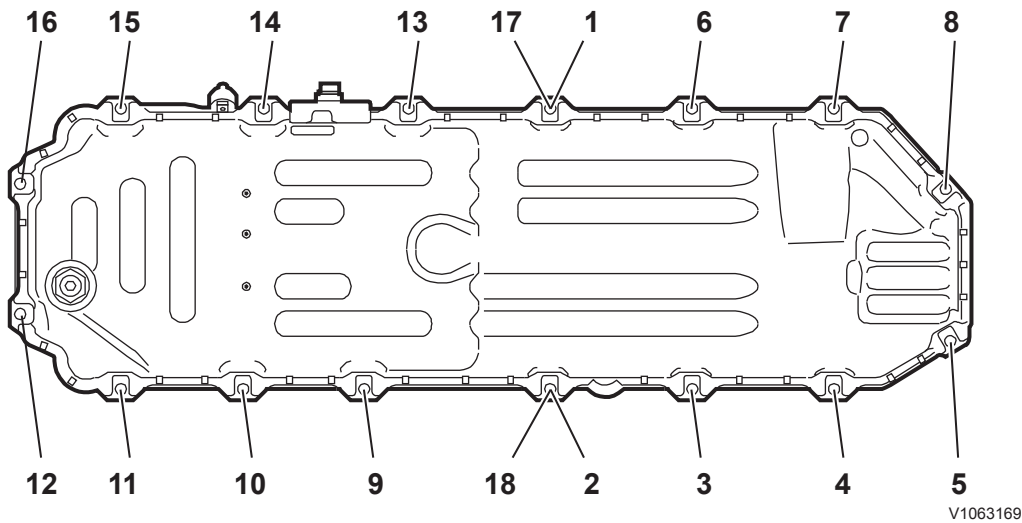


Fig.12 The illustration shows the oil sump for engine D13H, there may be some differences.

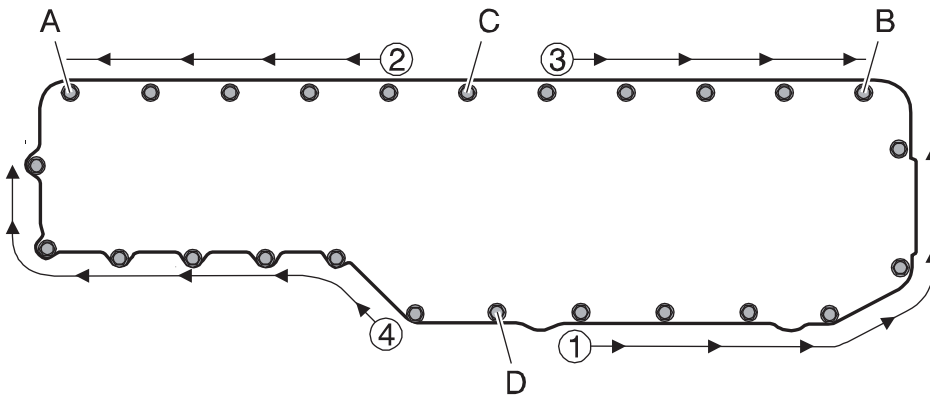
Oil sump NOTE! Tighten the bolts in the numerical order shown in the figure.	24±4 Nm (18±3 lbf ft)
Drain plug, oil sump	52±8 Nm (38±6 lbf ft)

Oil cooler, tightening torques

Oil cooler

Oil cooler, attaching bolts	Nm	lbf ft
Tighten the bolts crosswise	27 ±4	19,9 ±2,95

Oil cooler, cover



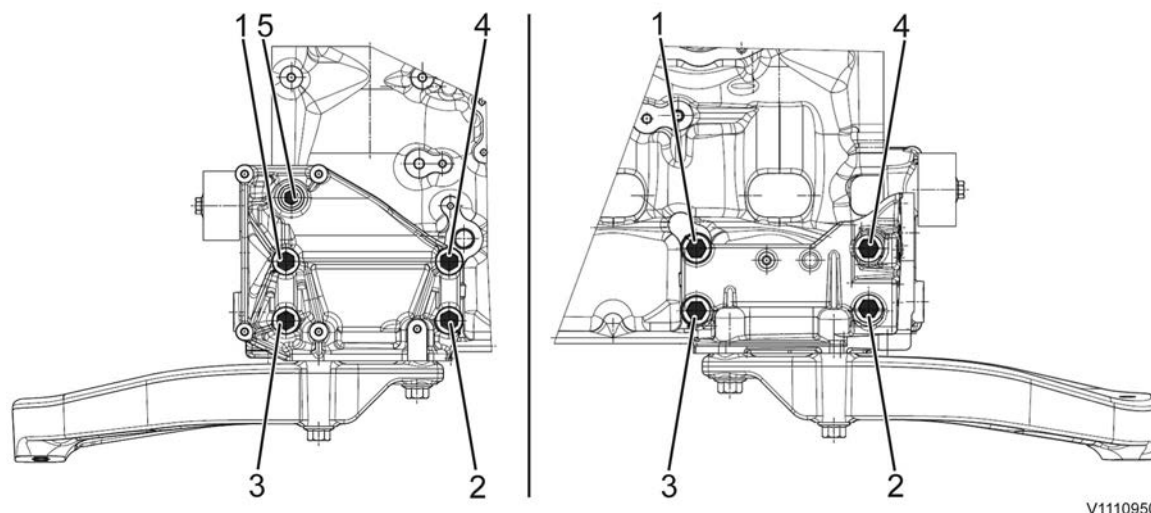
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Fig.13

Oil cooler, cover:	Nm	lbf ft
Install the cover on the engine block and fit bolt A in the oval hole		
Press the cover against the coolant pump housing with the special tool and install bolt B		
Install bolts C and D and tighten them	24 ±4	17.7 ±2.95
Tighten the cover's bolts in order, according to diagram	24 ±4	17.7 ±2.95
Finish by tightening bolts C and D again	24 ±4	17.7 ±2.95

Cylinder block, tightening torques

Engine mount incl. bracket



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Fig.14 Front engine mount bracket

Front engine mount bracket, cylinder block:	
Step 1: Tighten bolt 1.	80 ±15 Nm (59 ±11 lbf ft)
Step 2: Tighten bolts 2 — 4.	105±15 Nm (77.4±11 lbf ft)
Step 3: Angle-tighten bolts 2 — 4 in numerical order	60 ±5°
Step 4: Tighten bolt 1	105±15 Nm (77.4±11 lbf ft)
Step 5: Angle-tighten bolt 1	60 ±5°
Step 6: Tighten bolt 5	Standard bolt tightening torque
Front engine mount to frame	140±25 Nm (103.3±18.4 lbf ft)
Rear engine mount, flywheel housing:	
EXC	262±26 Nm (193.2±19 lbf ft)

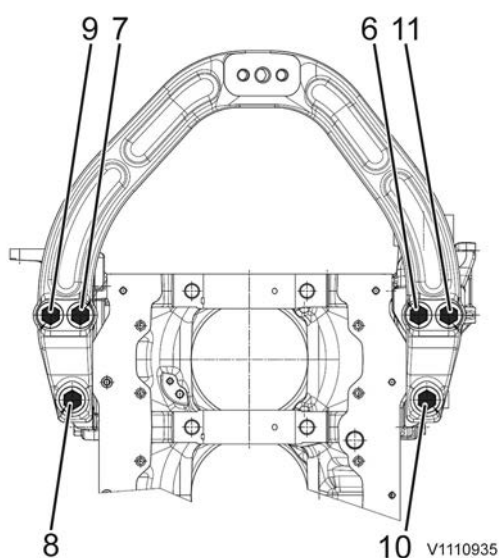
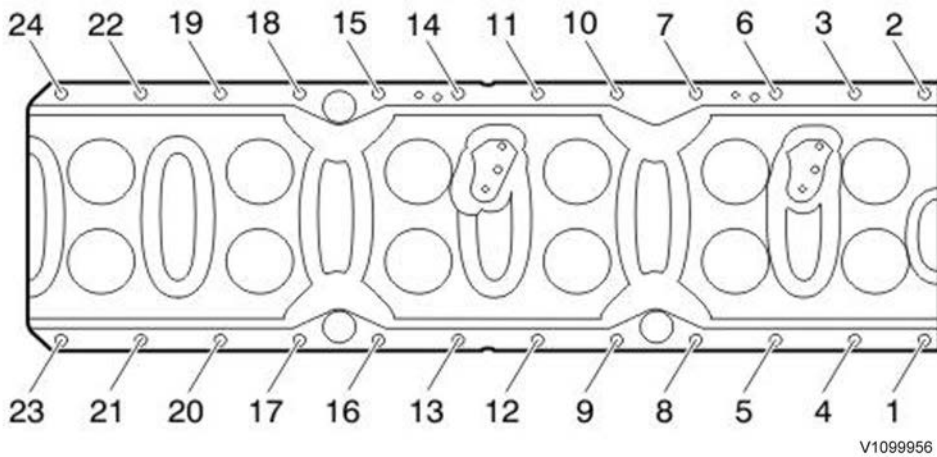


Fig.15 Front engine mount

Front engine mount to engine mount bracket	
Step 1: Tighten bolts 6 – 11	5 ±2 Nm (3.7 ±1.5 lbf ft)
Step 1: Tighten bolts 6 – 11	275 ±45 Nm (203 ±33 lbf ft)

Ladder frame



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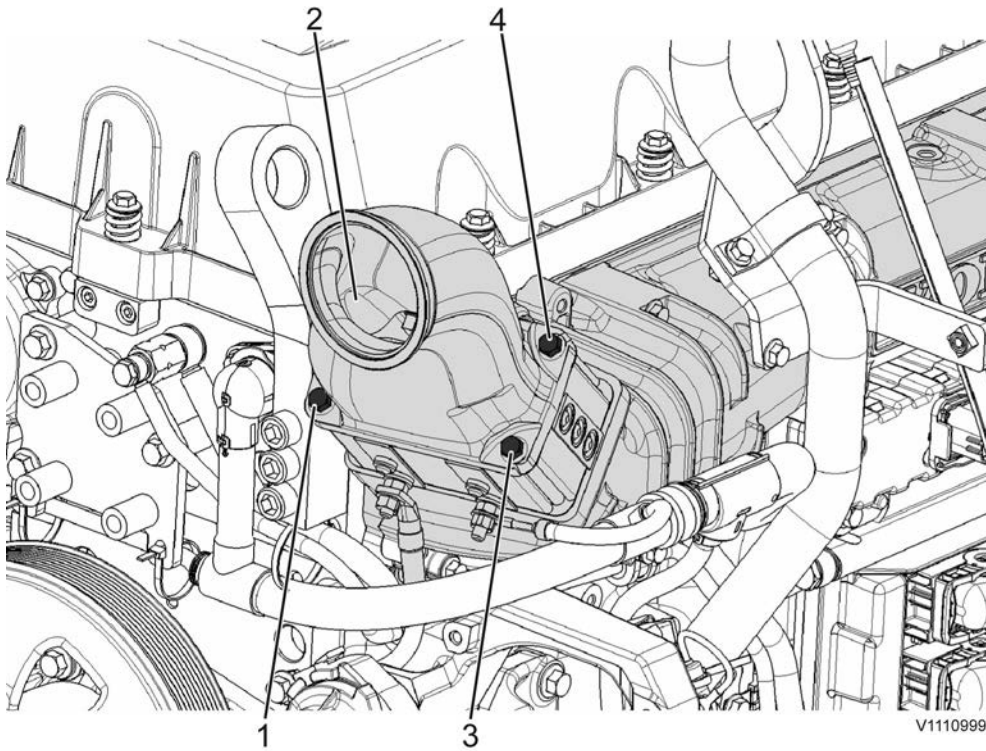
Fig.16 Ladder frame

Ladder frame	
Step 1: Tighten bolts 1 — 24 in numerical order	45±5 Nm (33.19±3.69 lbf ft)
Step 2: Tighten bolts in numerical order 1 — 24 (angle-tightening)	60 ±5°
Timing gear plate:	
M8-bolts	28±4 Nm (20.7±2.95 lbf ft)
Main bearing caps:	
Step 1	150±20 Nm (110.6±14.8 lbf ft)
Step 2 (angle-tightening)	120 ±5°
Connecting rod (big-end) caps:	
Step 1	20±3 Nm (14.8±2.2 lbf ft)
Step 2	60±3 Nm (44.3±2.2 lbf ft)
Step 3 (angle-tightening)	90 ±5°
Press tool for measuring liner height	40 Nm (29.5 ft lbf)

Inlet

NOTE!

Tighten the bolts according to the numerical order in the figure.
The bolts shall not be reused.



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Fig.17 WLO, EXC: Mixing chamber, preheater

Inlet pipe	
Mixing chamber, preheater:	
Step 1	10±2 Nm (7.38±1.48 lbf ft)
Step 2	24±3 Nm (17.7±2.21 lbf ft)
Plug, M10 (inlet pipe)	20±3 Nm (14.8±2.2 lbf ft)

NOTE!

Torque-tighten the bolts diagonally as shown in the figure.

Tightening torque, fuel system

Bolt, fastener yoke, unit injectors.	Copper sleeve	Steel sleeve
step 1	25 +5/-0 Nm (18.4 +3.7/-0 lbf ft)	20 Nm +5/-0 (14.8 +3.7/-0 lbf ft)
step 2	90° ±5°	90° ±5°
New sleeve or new cylinder head		
Bolt, fastener yoke, unit injectors	Copper sleeve	Steel sleeve
step 1	30 +5/-0 Nm (22 +3.7/-0 lbf ft)	20 +5/-0 Nm (14.8 +3.7/-0 lbf ft)
step 2	150° ±5°	180° ±5°
Step 3: Loose the yoke's bolt until the torque is	10–15 Nm (7.4–11 lbf ft)	10–15 Nm (7.4–11 lbf ft)
step 4	25 +5/-0 Nm (18.4 +3.7/-0 lbf ft)	20 +5/-0 Nm (14.8 +3.7/-0 lbf ft)
step 5	90° ±5°	90° ±5°
Lock nut for adjusting screw, unit injectors	52 ±4 Nm (38.4 ±lbf ft)	
Banjo screw, fuel hose		
M10	18 ±3 Nm (13.3 ±2.2 lbf ft)	
M12	26 ±4 Nm (19.2 ±2.9 lbf ft)	
M14	38 ±6 Nm (28 ±4.4 lbf ft)	
M16	48 ±8 Nm (35.4 ±6 lbf ft)	
Fuel pump (mounted on oil pump)	8 +2/-0 Nm (5.9 +1.5/-0 lbf ft)	
Oil pump	24 ±2 Nm (17.7 ±1.5 lbf ft)	
Unit injectors, preload	Tighten the adjusting screw to zero clearance against the camshaft, then turn it 240° ±20°	

Exhaust manifold, tightening torques

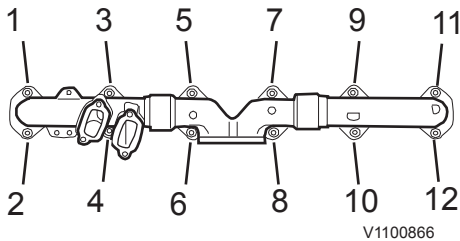


Fig.18

Step 1:	
Tighten bolts 1, 4, and 5, 8, and 9, 12 to contact	10±1.5 Nm (7.4±1.1 lbf ft)
Step 2:	
Tighten bolts 3 and 2	48±8 Nm (35.4±5.9 lbf ft)
Tighten bolts 7 and 6	48±8 Nm (35.4±5.9 lbf ft)
Tighten bolts 11 and 10	48±8 Nm (35.4±5.9 lbf ft)
Tighten bolts 1 and 4	48±8 Nm (35.4±5.9 lbf ft)
Tighten bolts 5 and 8	48±8 Nm (35.4±5.9 lbf ft)
Tighten bolts 9 and 12.	48±8 Nm (35.4±5.9 lbf ft)

Turbocharger, tightening torques

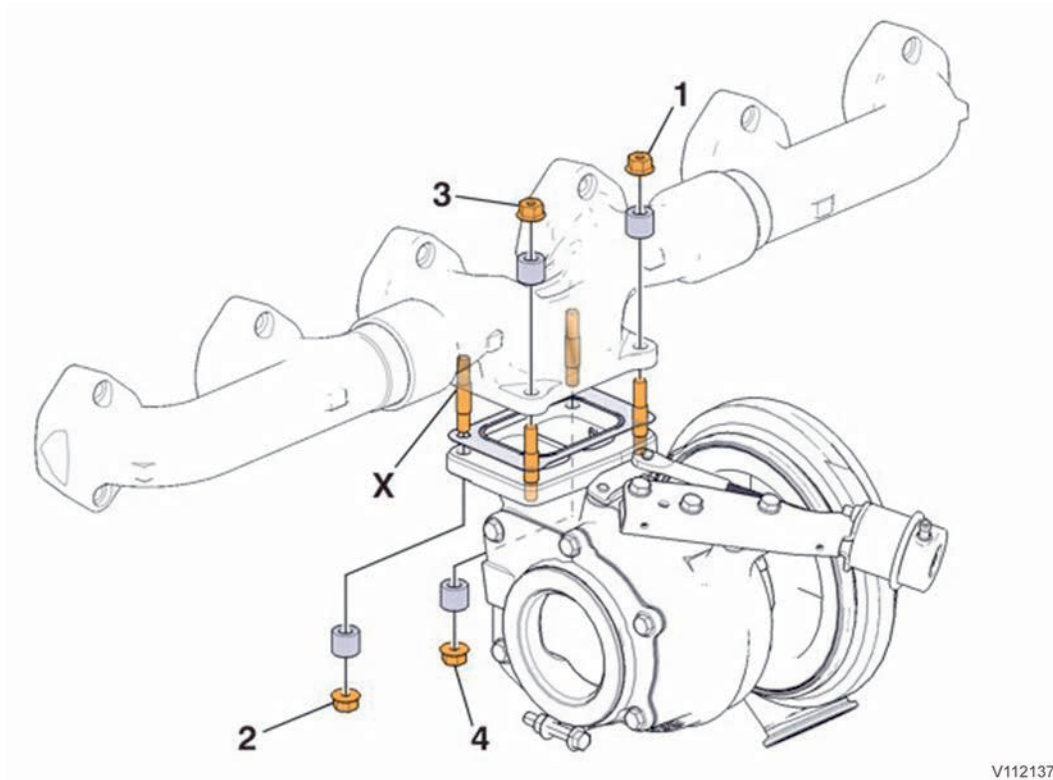


Fig.19 Bolts for installing the turbocharger to the exhaust manifold.

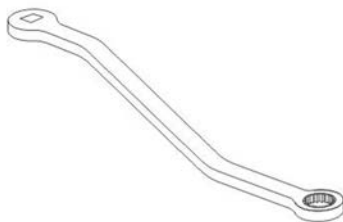
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NOTE!

Torque-tighten bolts diagonally as shown in the figure.

Table. Against exhaust manifold

Position 1 and 3	
step 1	20 ±4 Nm (14.8 ±3 lbf ft)
step 2	48 ±8 Nm (35.4 ±6 lbf ft)
Position 2 and 4 — using the tool 88830179 Wrench	
step 1	16,8 Nm (12.2 lbf ft)
step 2	40,2 Nm (29.6 lbf ft)



V1121581

Fig.20 88830179 Wrench, for position 2 and 4

Table. Connections for coolant and lubrication oil

Tightening torques, turbo	
Coolant lines	38±6 Nm (28±4.4 lbf ft)
Oil lines	48±5 Nm (35.5±3.7 lbf ft)

Table. Charge-air cooler pipe

Clamps	8,5±0,8 Nm (6.3±0.6 lbf ft)
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Crank mechanism, specifications

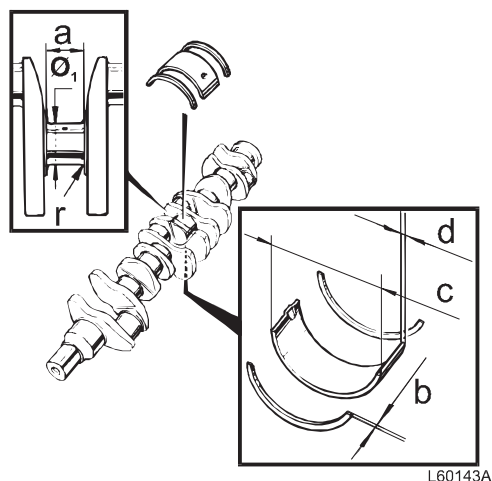


Fig.21

Crankshaft	
Length	1 153.8 mm (45.4 in)
Crankshaft, max. axial clearance	0.4 mm (0.016 in)
Max. permitted ovality of main bearing and big-end bearing pins	0.006 mm (0.00024 in)
Max. permitted conicity of main bearing and big-end bearing pins	< 0.02 mm (< 0.0008 in)
Max. run-out of middle bearing	0.15 mm (0.0059 in)

Main bearing pin	
Diameter (\varnothing) for reworking, standard	108.0 mm (4.25 in)
surface finish, main bearing pin	Ra 0.25 mm (0.00098 in)
surface finish, radius	Ra 0.4 mm (0.00044 in)
Width, thrust bearing pin (a), standard	47.0 mm (1.85 in)
Fillet radius (r)	4.0 mm (0.157 in)

Thrust washers (thrust bearings)	
Width (b), standard	3.18 mm (0.125 in)
Oversize:	
0.1 mm (0.0039 in)	3.28 mm (0.129 in)
0.2 mm (0.0079 in)	3.38 mm (0.133 in)
0.3 mm (0.0118 in)	3.48 mm (0.137 in)
0.4 mm (0.0157 in)	3.58 mm (0.141 in)

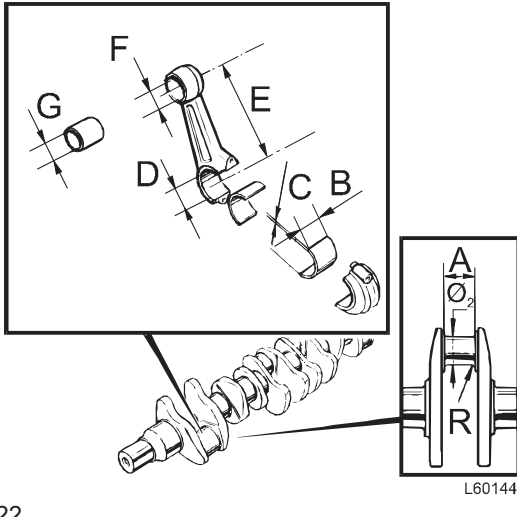


Fig.22

Main bearing shells	
Type	Replaceable
Outer diameter (c)	113.065 mm (4.451 in)
Thickness (d), standard	2.485 mm (0.098 in)

Crankshaft bearing pins	
Diameter (Ø) for reworking, standard	99 mm (3.897 in)
Surface finish, crankshaft bearing pin	Ra 0.25
Surface finish, radius	Ra 0.4
Width (A)	57 mm (2.244 in)
Fillet radius (r)	4.0 mm (0.157 in)

Connecting rods' bearing shells	
Outer diameter (B)	103.85 mm (4.088 in)
Thickness (C), standard	2.389 mm (0.094 in)
Diameter, bearing shell's bearing seat (D)	103.835 mm (4.088 in)

Connecting rod	
Length, centre – centre (E)	267.5 mm (10.53 in)
Marking: "FRONT" on rod shall be turned to face the front. Connecting rods and caps are pair-marked with a three-digit running number.	
Connecting rod bushing's internal diameter (G)	58 mm (2.283 in)
Axial clearance, connecting rod – crankshaft, with marking directly opposite each other	< 0.35 mm (<0.014 in)
Big-end bearing, radial clearance, oiled part	< 0.10 mm (0.0039 in)
Straightness (max.) deviation per 100 mm measured length	0.06 mm (0.0024 in)
Twisting (max.) deviation per 100 mm measured length	0.15 mm (0.0059 in)

Piston	
Height above cylinder block face	0.15–0.21 mm (0.006– 0.008 in)
Number of ring grooves	3
Front marking	Arrow facing forward

Piston rings	
Compression rings	
Quantity	2
Piston ring clearance in groove: upper compression ring lower compression ring	Trapezium-shaped profile 0.09–0.14 mm (0.003– 0.005 in)
Piston ring gap in ring opening: upper compression ring lower compression ring	0.40–0.55 mm (0.0157– 0.0216 in) 1.30–1.50 mm (0.051– 0.059 in)
Oil scraper ring	
Quantity	1
Width incl. spring	3.41 mm (0.134 in)
Piston ring clearance in groove	0.05–0.10 mm (0.019– 0.039 in)
Piston ring gap in ring opening	0.30–0.55 mm (0.011– 0.021 in)

Crankshaft, tightening torques

Cover, crankshaft seal	
Step 1: Fasten the cover with the bolts 2 and 7 and tighten to contact.	
Step 2: Tighten bolts 2 and 7	24±4 Nm (17.7±2.95 lbf ft)
Step 3: Tighten the bolts in numerical order 1, 3 — 6, 8 as shown in the figure.	24±4 Nm (17.7±2.95 lbf ft)

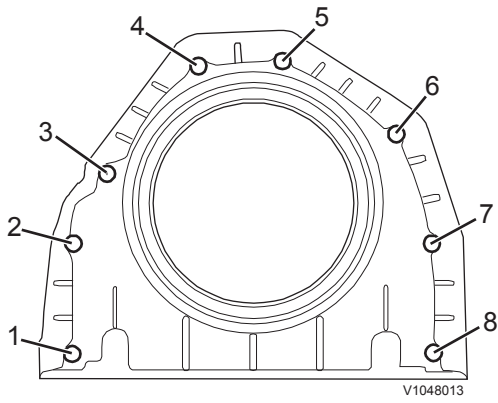


Fig.23

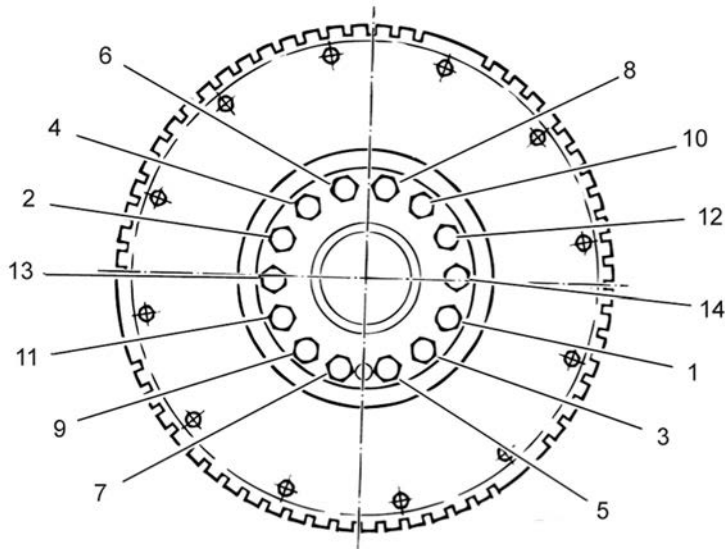
Flywheel, tightening torques

NOTE!

The bolts may only be reused twice, then new bolts shall be used.

Tighten the bolts in the order shown in the following figure. All bolts are tightened in two steps:

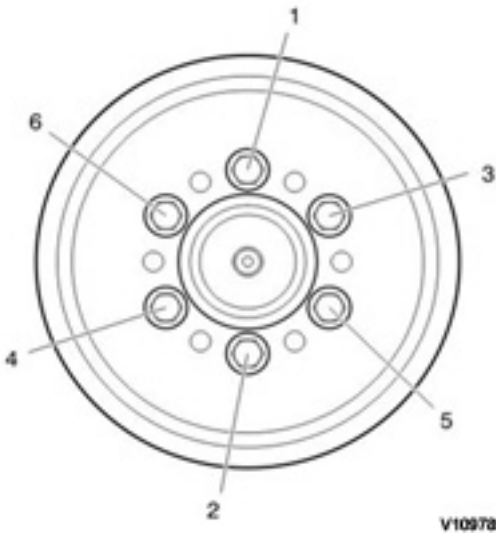
Step 1	60±5 Nm (44±3.7 lbf ft)
Step 2, angle-tightening	120°±10°



V1101948

Fig.24 Flywheel

Belt pulley/vibration damper, tightening torques



V1097899

Fig.25 Belt pulley/vibration damper

Vibration damper and belt pulley	
Step 1, according to numerical order in figure:	35±5 Nm (25.8±3.7 lbf ft)
Step 2, according to numerical order in figure:	90±10 Nm (66.4±7.4 lbf ft)

ENGINE WITH MOUNTING AND EQUIPMENT

21 ENGINE

210 General, common info about 211 - 218

Engine, mounting in work stand

Op. no. 210-081

Tools:

9986485 Support

88800345 Fixture

88800123 Fixture

Lifting eye, 2 pcs.

Sling 3 m (118 in)

Ratchet block 1,500 kg (3307 lbs)

NOTE!

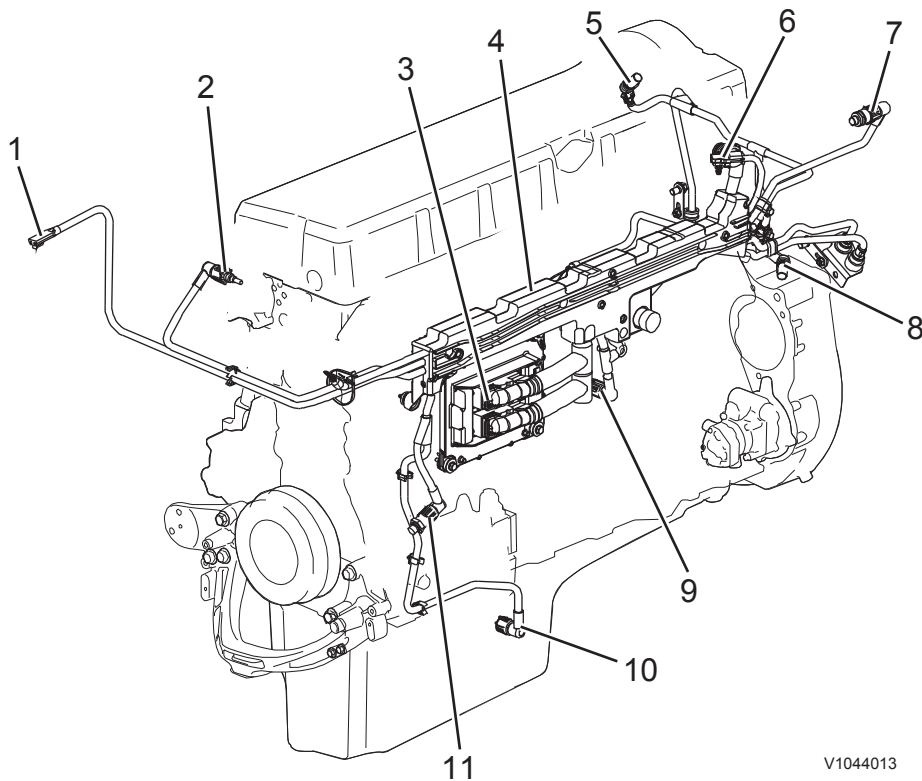
Since the engine illustrations in the service publications are reused for different engine versions, some parts may vary from the version in question. However, the essential information in the illustrations is always correct.

Engine D13F, weight:

WLO **approx. 1,330 kg (3,932 lbs)**

EXC **approx. 1,330 kg (3,932 lbs)**

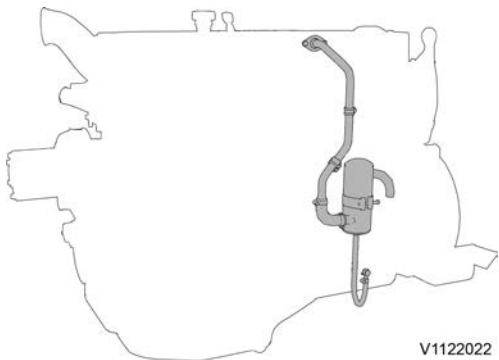
- 1 Unplug the sensors and the cable harness. Unplug the connectors from the E-ECU. Remove the cable channel.



V1044013

Fig.26 Sensor, control system

- 1 Sensor for coolant level, SE2603
- 2 Sensor for coolant temperature, SE2606
- 3 E-ECU
- 4 Cable channel
- 5 Camshaft sensor, engine position, SE2703
- 6 Sensor for boost pressure/charge-air temperature, SE2507/SE2508
- 7 Sensor for air pressure/air temperature, SE2501/SE2502
- 8 Speed (rpm) sensor, flywheel, SE2701
- 9 Sensor for oil pressure, SE2203
- 10 Sensor for oil level/oil temperature, SE2205/SE2202
- 11 Sensor for crankcase pressure, SE2509

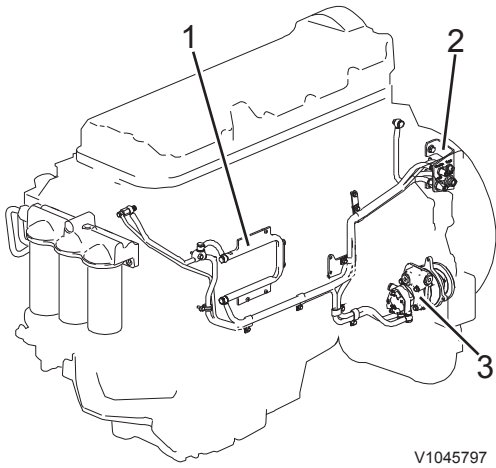


V1122022

Fig.27 Oil trap with hose and pipe

- 2 Disconnect the oil trap hose from the oil sump. Disconnect the oil trap pipe from the valve cover. Remove the oil trap, pipe and hose.

NOTE!
Collet the waste oil in a suitable container.

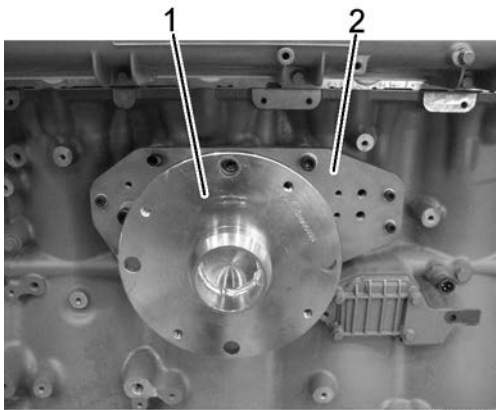


V1045797

Fig.28 Fuel lines

- 1 Cooling circuit, E-ECU
- 2 Bracket — different location for EXC
- 3 Fuel pump

- 3 Disconnect the fuel lines from the cylinder block, E-ECU, cylinder head, and the fuel pump. Remove the bracket (for the fuel connections, also know as fuel interface).
- 4 Remove the E-ECU.

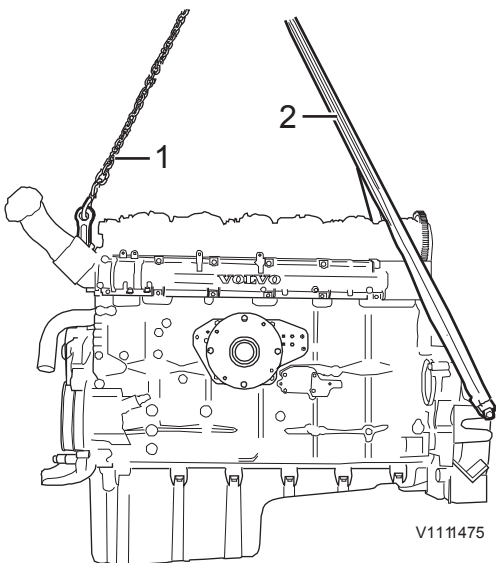


V1045737

Fig.29

- 1 88800345 Fixture
- 2 88800123 Fixture

- 5 Install 88800123 Fixture and 88800345 Fixture and tighten with torque.



V1111475

Fig.30

- 1 Ratchet block
- 2 Sling

- 6 Install the ratchet block and sling on the engine and connect the engine to the lifting device. Install the engine in 9986485 Support.

Secure the engine by placing three axle stands under the engine.

NOTE!

If the engine is heavier than the stand's weight-bearing classification the engine must rest on three axle stands that are placed under the engine before the lifting device is removed.

Engine, dismantling

Op. no. 210-077

Tools:

11666054 Jack
88830175 Pump
9990114 Puller
88800352 Lifting tool
9990262 Adapter
9992955 Puller plate
9993590 Gear wheel
9993717 Quick nut
9993717 Quick nut
9993722 Support
9993791 Puller bolt
9996400 Impact puller
9998267 Guide
88830179 Wrench

Sling 1 m (39 in)

Feeler gauge

NOTE!

Since the engine illustrations in the service publications are reused for different engine versions, some parts may vary from the version in question. However, the essential information in the illustrations is always correct.

This operation also includes tools and times necessary for applicable parts of the following actions:

- *Cylinder head, removing page 59*
- *Valves, adjusting page 88*

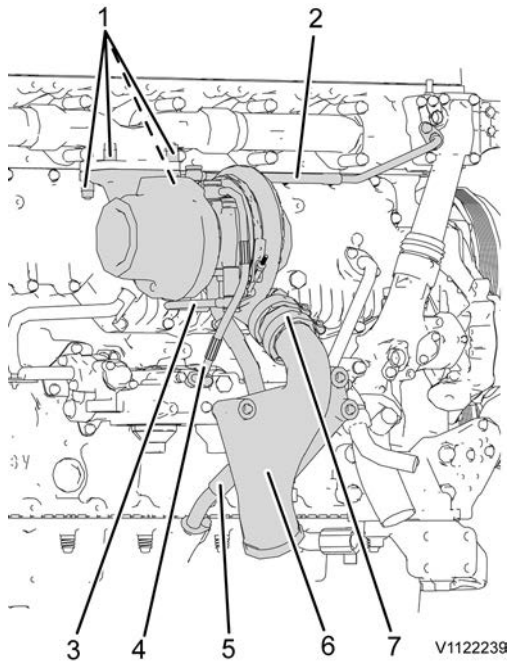


Fig.31

- 1 Bolts connecting the turbo with the exhaust manifold
- 2 Coolant line for turbo cooling
- 3 Coolant line
- 4 Oil pressure hose
- 5 Oil return hose
- 6 Charge-air cooler pipe
- 7 Clamp for charge-air cooler

- 1
 - Remove the clamps and hose for the charge-air cooler.
 - Remove the charge-air cooler pipe.
 - Remove the coolant lines for turbo cooling.
 - Loosen the end of the oil pressure and return hoses at the turbocharger.
 - Loosen the rear bolts for the turbocharger.
 - Connect a lifting device to the turbocharger.
 - Drain the oil.
 - Remove the front bolts and remove the turbocharger with the lifting device. For WLO — remove the turbocharger including the waste gate.
 - Remove the rear bolts for the turbocharger and the gasket.
 - Remove the oil hoses.

Turbo, weight: **approx. 28 kg**

NOTE!

Collect the waste oil in a suitable container.

- 2 Remove the exhaust manifold.
- 3 Remove the coolant pipe between the cylinder head and the coolant pump.

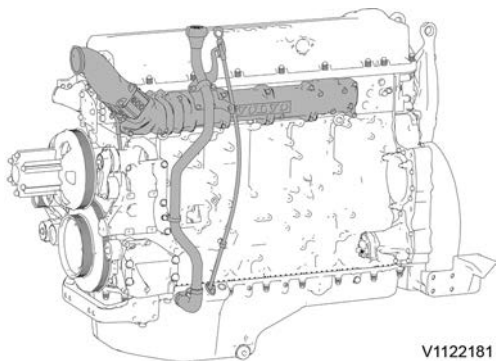


Fig.32 Oil filler pipe, oil dipstick, inlet manifold with preheating coil.

- 4
 - Remove the lower bolt for the oil filler pipe.
 - Remove the oil filler pipe.
 - Remove the oil dipstick.
 - Remove the inlet manifold with the preheating coil.
- 5 Remove the lift plate.
- 6 Remove the valve cover.

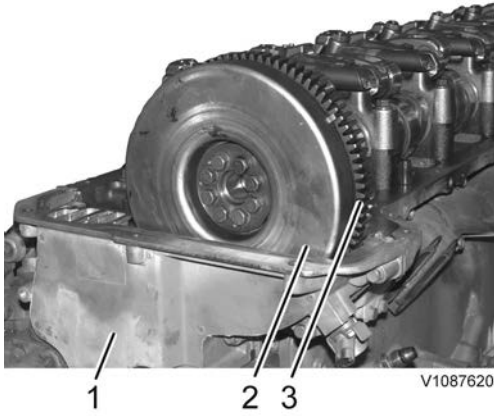


Fig.33

- 1 Upper timing gear casing
- 2 Vibration damper
- 3 Camshaft gear

- 7 - Remove the upper timing gear casing.
- Remove the vibration damper and the camshaft gear.
- 8 Remove the cylinder head according to *Cylinder head, removing page 59*.
- 9 Remove the oil filters and the pipes for the oil filters. — only WLO

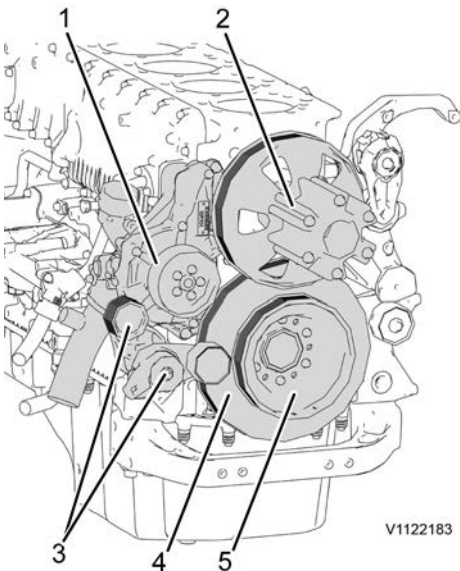


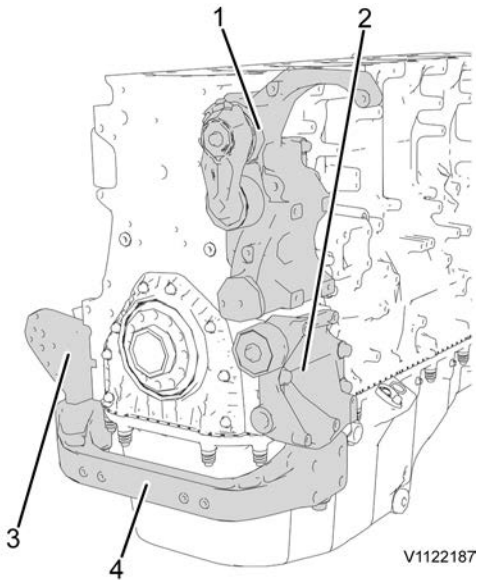
Fig.34

- 1 Coolant pump
- 2 EXC: Fan hub / WLO: Upper belt pulley
- 3 Tensioner pulleys
- 4 Vibration damper
- 5 Lower belt pulley

NOTE!

Collect the waste oil in a suitable container.

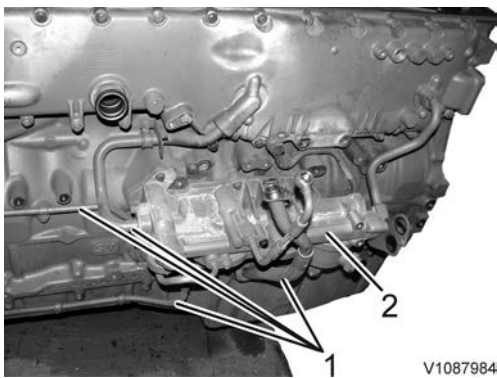
- 10 - For EXC — remove the fan hub. For WLO — Remove the upper belt pulley.
- Remove the lower belt pulley.
- Remove the tensioner pulleys.
- Remove the vibration damper.
- 11 Remove the coolant pump.



- 12 - Remove the front engine mount.
- Remove the belt tensioners, idlers and brackets.

Fig.35

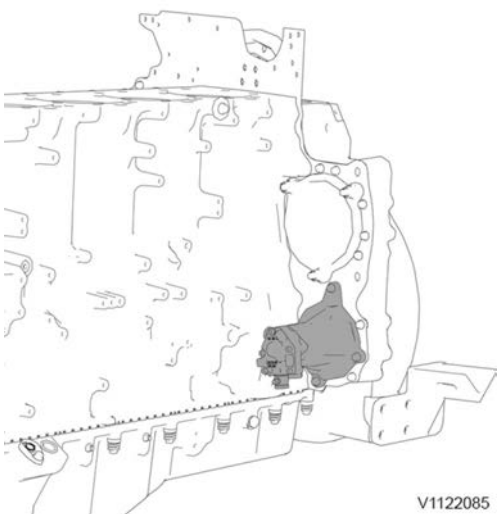
- 1 Bracket for AC compressor and alternator
- 2 Bracket with belt tensioner
- 3 Bracket for belt tensioners
- 4 Front engine mount



- 13 Remove the filter housing and the pipes.

Fig.36

- 1 Pipe
- 2 Filter housing



- 14 Remove the fuel pump.
- 15 Disconnect the lubrication oil lines from the oil sump.
- 16 Remove the oil sump.
- 17 Install 9993590 Gear wheel in the flywheel housing to prevent the crankshaft from rotating.
- 18 Loosen the bolts for the flywheel (12 pcs.).

Fig.37 Fuel pump

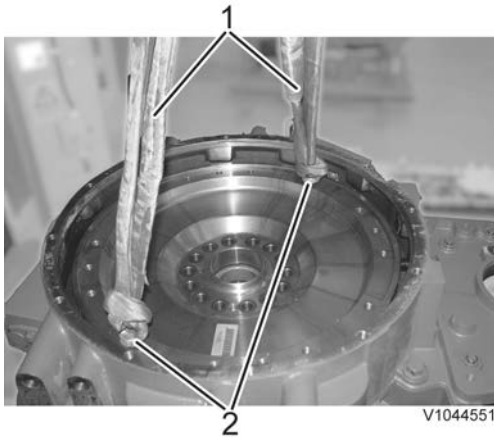


Fig.38

- 1 Sling 1 metre
- 2 M10 Lifting eye

- 19 Remove the flywheel.
Weight:
WLO **approx. 40 kg (88 lbs)**
EXC **approx. 75 kg (165 lbs)**
- 20 Install lifting eyes on the flywheel housing and secure it.
- 21 Loosen the bolts on the flywheel housing and then lift away the flywheel housing.
Flywheel housing, weight: **approx. 200 kg (441 lbs)**
- 22 Rotate the engine 180°.

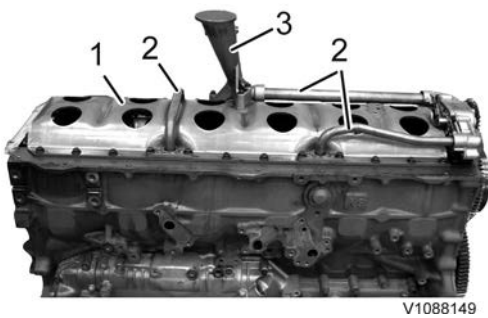


Fig.39

- 1 Ladder frame
- 2 Pipes for lubrication oil pump
- 3 Strainer

- 23 - Remove the strainer and the pipes for the lubrication oil pump.
- Remove the ladder frame.
- 24 Rotate back the engine 180°.



Fig.40

- 1 Oil cooler

- 25 Remove the oil cooler.
- 26 Rotate the engine 180°.
- 27 Remove the casing with the front crankshaft seal.
- 28 Remove the lubrication oil pump.
- 29 Remove the transfer gear for the fuel pump.



Fig.41

- 30 Loosen and remove the bolts that hold the double gear (6 pcs.). Remove the double gear.

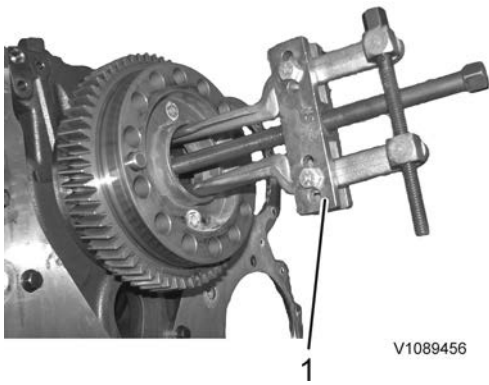


Fig.42
1 Internal puller

- 31
- Remove the rest of the bolts for the crankshaft gear.
 - Install an internal puller as shown in the figure.
 - Pull out and remove the gear.

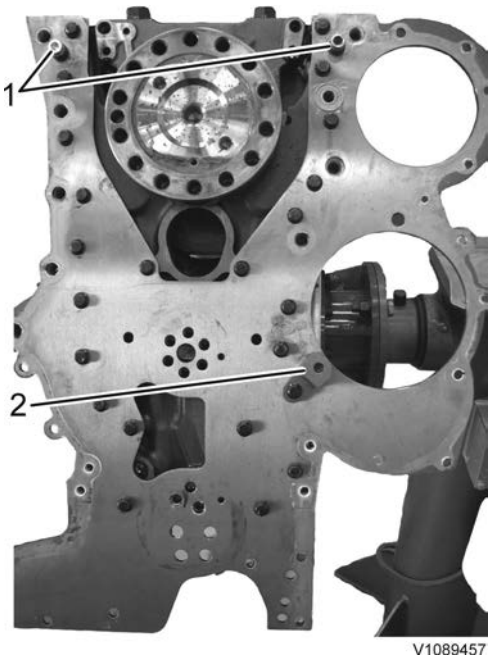


Fig.43
1 9998267 Guide.
2 Bracket

- 32
- Install 9998267 Guide (2 pcs.) and remove the bracket and bolts (23 pcs.) that hold the timing gear plate.
 - Carefully remove the timing gear plate.

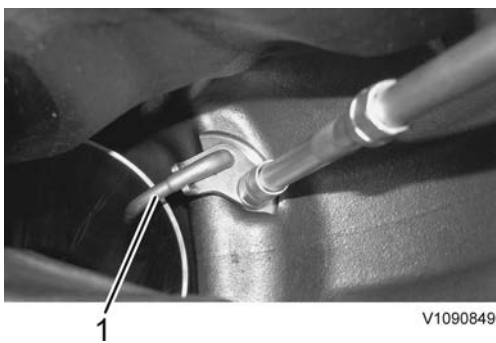


Fig.44
1 Piston cooling nozzle

- 33 Remove the piston cooling nozzles.

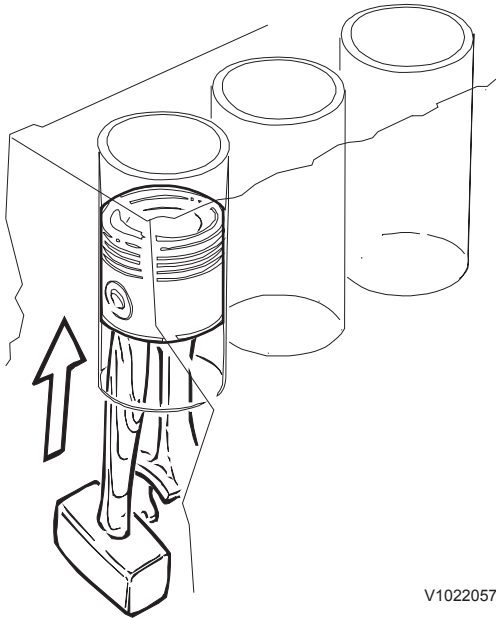


Fig.45

- 34 - Remove the bolts (4 pcs.), the caps, and carefully tap loose the piston and connecting rod.

NOTE!

- Avoid striking on the connecting rod's mating surfaces.
 - Repeat for the rest of the pistons and connecting rods.

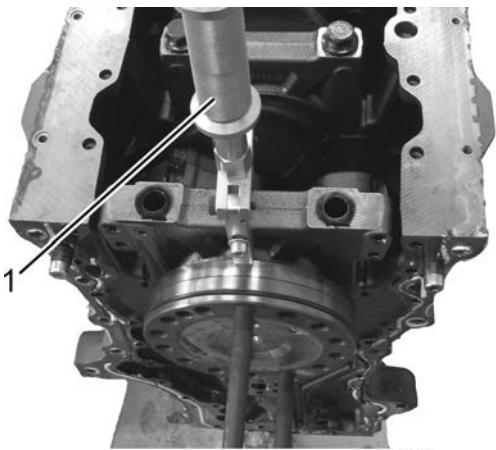


Fig.46

- 1 9996400 Impact puller, 9990114 Puller and 9990262 Adapter

- 35 - Remove the bolt and remove the main bearing cap.
 - Repeat for the rest of the main bearing caps. Note position of the main bearing caps for reinstalling later on.

NOTE!

- Save and keep track of the thrust bearings located on the 4th cylinder's main bearing.



Fig.47

- 36 Turn the crankshaft so that the 1st cylinder's and 6th cylinder's bellcranks are positioned straight up. Secure with lift slings in the lifting device and lift away the shaft. Crankshaft, weight: **approx. 125 kg (275 lbs)**. Remove the main bearings.

Cylinder liners, removing

37 Mark the position of the liners in the cylinder block and pull out the cylinder liners with the tools shown in the figure.

38 Remove the old seals.

NOTE!

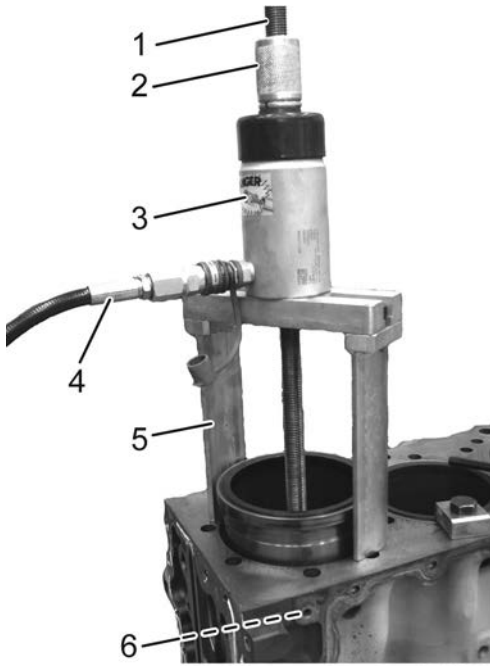
Work carefully so that the block is not damaged.

Thoroughly clean the grooves for the seals and the cylinder liner's sealing faces against the cylinder block. Thoroughly clean the sealing face on the liner shelf from rust, grease, and deposits.

NOTE!

Do not use any scraper tools made of metal.

39 Check the rest of the engine block's seals, connections, channels, etc. Clean, and replace any damaged parts.



V1090853

Fig.48

- 1 9993791 Puller bolt
- 2 9993717 Quick nut
- 3 11666054 Jack
- 4 88830175 Pump
- 5 9993722 Support (Use the long support legs)
- 6 9992955 Puller plate and 9993717 Quick nut

Engine, assembling

Op. no. 210-078

Tools:

885812 Timing tool
88800021 Installation tool
88800031 Setting tool
88800123 Fixture
88800318 Piston ring compressor
88800345 Fixture
88830179 Wrench
88880003 Bracket
9812524 Milling tool
88800352 Lifting tool
9990166 Installation tool
9992000 Handle
9992479 Retainer
9992663 Sealing plate
9992955 Puller plate
9993590 Gear wheel
9996662 Pressure gauge
9996684 Sealing plate
9996966 Press tool
9996966 Press tool
9996966 Press tool
9996966 Press tool
9996966 Press tool
9996966 Press tool
9996966 Press tool
9996966 Press tool
9996966 Press tool
9998143 Sealing plate
9998238 Drift
9998267 Guide
9998267 Guide
9998288 Sealing plate
9998318 Press tool
9998601 Installation tool

Sealant 1161231
Feeler gauge
Sling 1 m (39 in)
Sling 3 m (118 in)
Lifting eye 2 pcs.
Lifting eye M10, 2 pcs.
Dial indicator with magnetic stand

This operation also includes tools and times necessary for applicable parts of the following actions:

- *Cylinder block, liners removed, milling of all liner locations page 82*
- *Cylinder head, fitting page 76*
- *Oil cooler, leakage check page 91*
- *Engine, removing from work stand page 56*

Cylinder liners, installing

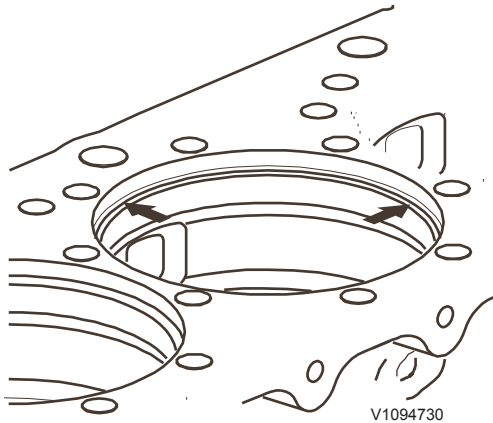


Fig.49

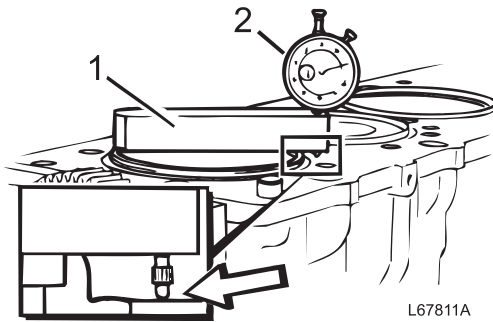


Fig.50

- 1 9992479 Retainer
- 2 Dial indicator

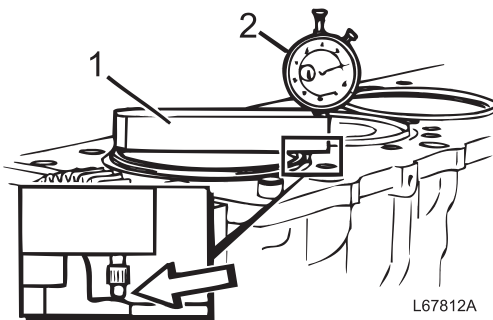


Fig.51

- 1 9992479 Retainer
- 2 Dial indicator

- 1 Check the cylinder block's liner shelves for any damage. If the liner shelf is damaged it must be overhauled. See *Cylinder block, liners removed, milling of all liner locations page 82*.
Install the cylinder liners without O-rings and fixate them with 9996966 Press tool.
Tightening torque press tools, see *Cylinder block, tightening torques page 18*.
- 2 Install a dial indicator in 9992479 Retainer. Place the holder with the dial indicator across the cylinder liner. Reset the dial indicator to zero with a couple of millimetres preload against the cylinder block's face.
- 3 Measure the height between the cylinder liner and the cylinder block's face. Measure the liner's height at two different points diagonally opposite to each other.

NOTE!

The sealing face is convex. Always measure at the highest point on the sealing face.

Calculate the average value of both measurements.

For correct liner height over the block face, see *Cylinder block, specifications page 7*.

If the liner's height over the block face is higher than the stated tolerance, then the liner shelf in the cylinder block has to be milled. Milling should take place at an authorized workshop.

See *Cylinder block, liners removed, milling of all liner locations page 82*.

Mark the liner's position in the cylinder block with a magic marker, so that it ends up in the same position when installing. Repeat the procedure for the rest of the cylinder liners.

- 4 Remove the press tools.
Pull the cylinder liners out of the block with 9992955 Puller plate. Place the cylinder liners in the same order that they were installed, together with their adjusting shims.

Adjusting shims for adjusting cylinder liner height are available in different thicknesses, see the Parts catalogue.

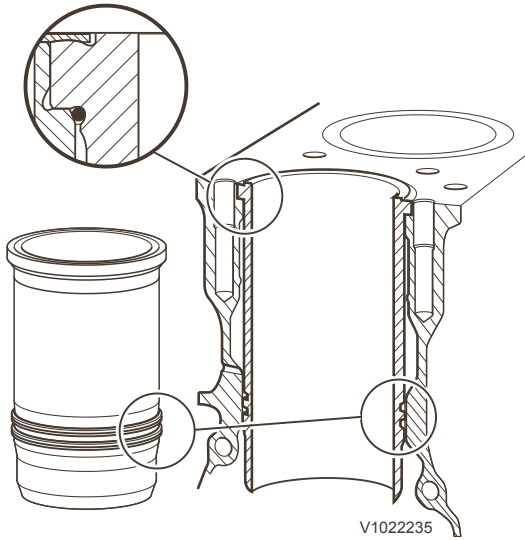


Fig.52

- 5 Lube the seal rings with the lubricant that is supplied with the liner kit and install them on the cylinder liner.

NOTE!

The violet seal ring shall be installed in the bottom groove.

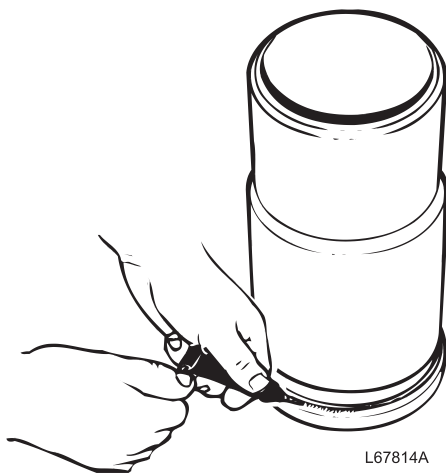


Fig.53 Applying sealant

- 6 If the cylinder liner is installed without shims, a uniform sealant bead approx. **0.8 mm (0.031 in)** thick shall be applied on the underside of the cylinder liner's collar. Leave a gap of **1-2 mm (0.039-0.079 in)** in the bead. Note that when replacing cylinder liners, use the sealant that is supplied in the cylinder liner kit.

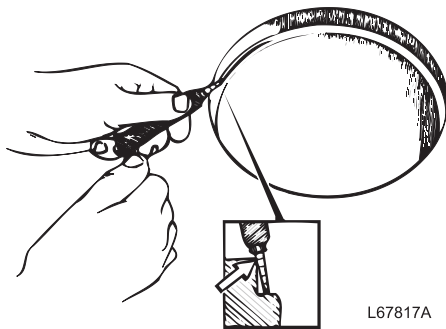


Fig.54 Applying sealant when adjusting shims are used

- 7 If adjusting shims are used, apply the sealant bead on the liner shelf in the cylinder block.

NOTE!

No sealant between the adjusting shims and the cylinder liner collar.

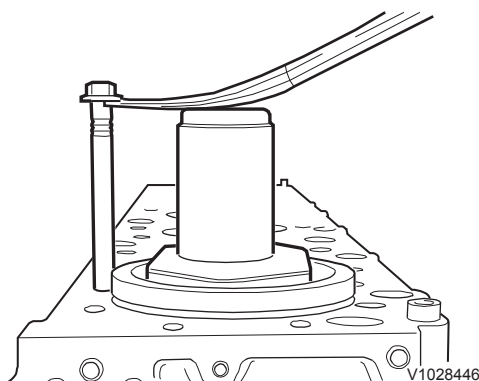


Fig.55 Installing cylinder liner

- 8 Install one of the cylinder head's bolts. Place 9992955 Puller plate on top of the cylinder liner together with a **90 mm (3.54 in)** spacer. Press down the cylinder liner with a pry bar. Install two 9996966 Press tool to lock the cylinder liner in the cylinder block. Repeat the procedure for the rest of the cylinder liners.

Crankshaft, installing

- 9 Install and check that the main bearing shells end up in the correct position in the engine block. Oil in the main bearing shells and the main bearing journal with engine oil.

NOTE!

Check that each main bearing shell's pressed-out lug ends up in the correct position in the bearing position's slot. Check that the upper bearing shells are provided with oil holes.

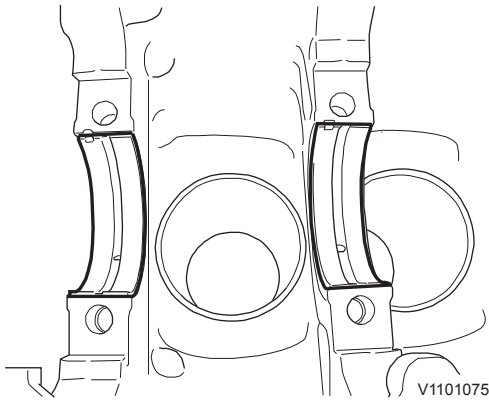


Fig.56 Main bearing shells

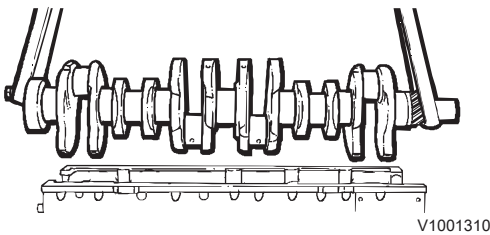


Fig.57 Crankshaft

- 10 Check that the crankshaft is free from damage. Carefully lift the crankshaft into place in the engine block. **Weight: approx. 125 kg (275 lbs)**

NOTE!

Make sure that the crankshaft faces the right way in relation to the block.

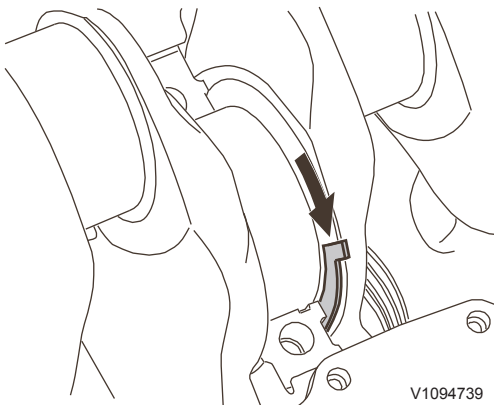


Fig.58 Thrust bearing washers

- 11 When the crankshaft is lowered against the main bearings, check that they are still in correct position. Install the thrust bearing washers so that the guide pin ends up in the intended slot.

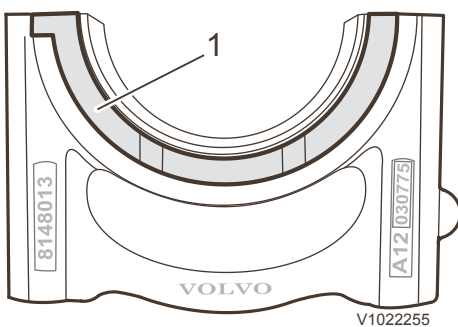


Fig.59

- 1 Thrust bearing washer

- 12 Fasten the other two thrust bearing washers with grease on the corresponding main bearing cap. Turn the washers so that the surfaces with oil grooves face the crankshaft's axial bearing surfaces.

NOTE!

The thrust bearing washers are available in three different oversizes, see *Crank mechanism, specifications page 23*

NOTE!

The fixing slots mean that the thrust bearing washers can only be installed in one position.

- 13 Check that the slots in the main bearings shells are located directly opposite each other on the main bearings in the cylinder block and bearing caps, respectively.

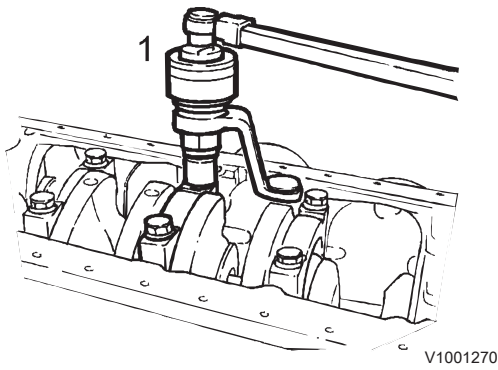


Fig.60
1 Torque multiplier

- 14 Install the main bearing caps.
Tighten down the main bearing caps according to *Cylinder block, tightening torques page 18*.

NOTE!

The bearing caps are marked. The arrow shall point in the direction of the engine's inlet side.

Pistons, installing

- 15 Assemble the piston and connecting rod.

NOTE!

Turn the piston rings so that they face according to their marking.

- 16 Rotate the engine to horizontal position. Oil in the piston. Check that the piston rings' gap are displaced 120° in relation to each other. Install the piston and connecting rod with arrow and front marking facing the front, towards the coolant pump. Use 88800318 Piston ring compressor to guide down the piston rings in the cylinder liner.

NOTE!

9996966 Press tool shall be removed temporarily when 88800318 Piston ring compressor is used. When the piston is in place, reinstall the press tool.

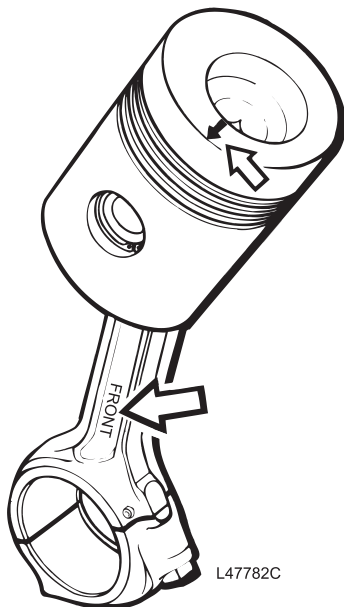


Fig.61 Marking on piston and connecting rod

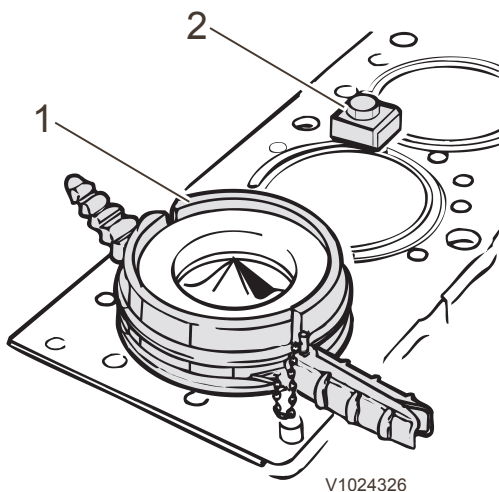


Fig.62
1 88800318 Piston ring compressor
2 9996966 Press tool



Fig.63 Tightening down bearing cap

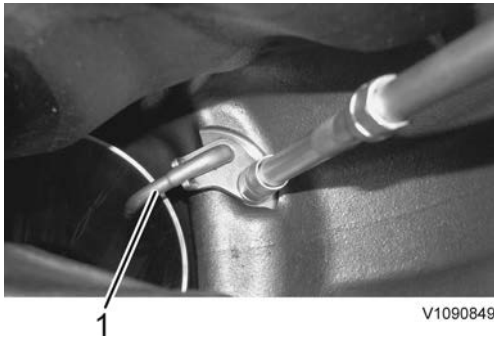


Fig.64
1 Piston cooling nozzle

- 17 Install the connecting rod (big-end) bearing caps. Check that the connecting rod and bearing cap are marked with the same number. Install two of the flywheel's bolts as a counterhold when rotating the crankshaft. Rotate the crankshaft until pistons 1 and 6 are in their bottom position. Tighten down the bearing caps with 885812 Timing tool for pistons 1 and 6. Repeat the procedure for the rest of the bearing caps.
Tightening torque: see *Cylinder block, tightening torques page 18*

- 18 Install the piston cooling nozzles. Check that the nozzles are directed at the pistons when they are in their bottom position.

NOTE!

Degrease the bolts and make sure that the threads and bolts are dry before installing. Use thread locker fluid, medium strength. Check that the nozzles are free from damage and that the fastener plate is flat against the cylinder block after tightening.

Installing timing gear plate

NOTE!

The timing gear plate should only be installed if it is absolutely necessary.

New cylinder block is delivered as spare part without timing gear plate.

- 19 Apply a 2 mm thick bead of sealant all the way around on the cylinder block and by the marked hole, as shown in the figure.

NOTE!

The sealant against the cylinder head is applied later on.

NOTE!

The timing gear plate must be installed within 20 minutes since the sealant hardens.

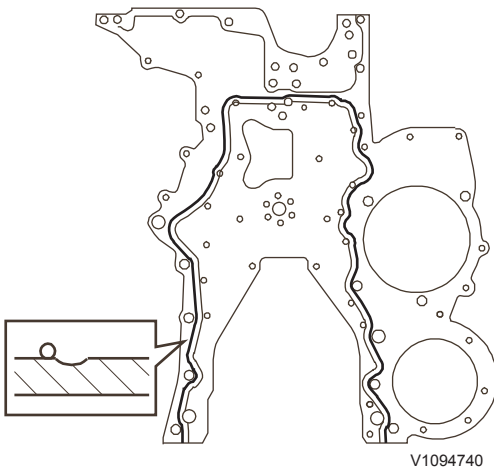


Fig.65

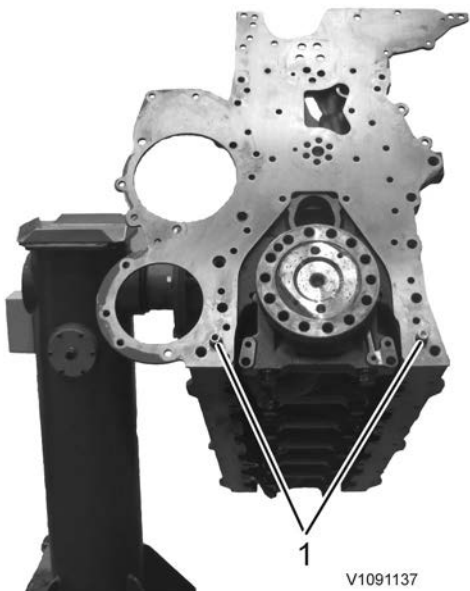


Fig.66
1 9998267 Guide

20 Place the timing gear plate in position using the guides that were installed earlier, 9998267 Guide.

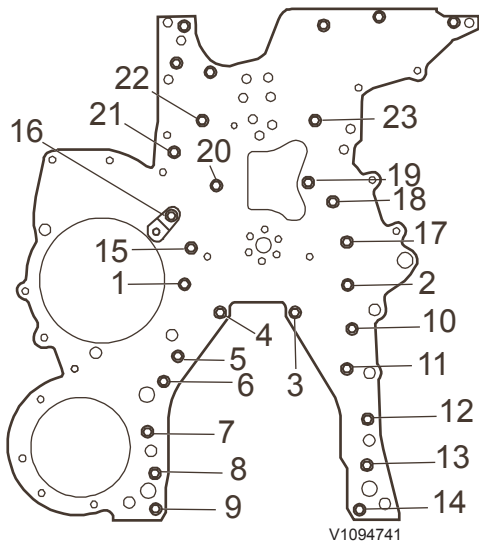


Fig.67

21 Install and tighten the bolts in the correct order as shown in the figure. Tighten the bolts according to: *Engine transmission, tightening torque page 7*

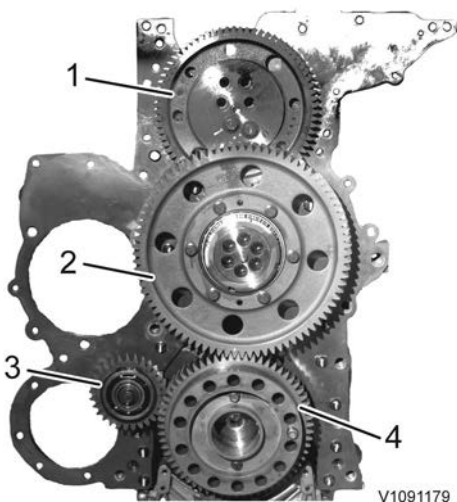


Fig.68
1 Adjustable gear
2 Double gear, cannot be overhauled
3 Transfer gear
4 Crankshaft gear

22 Install the O-ring on the crankshaft and lube it with lubricant. Lube the inside of the gear with the same lubricant. Align the gear's guide pin with the crankshaft's hole. Install the crankshaft gear.

23 Install the adjustable gear with its slide bearing. Fasten the bolts loosely.

24 Install the transfer gear.
Tightening torques, see *Engine transmission, tightening torque page 7*



V1091182

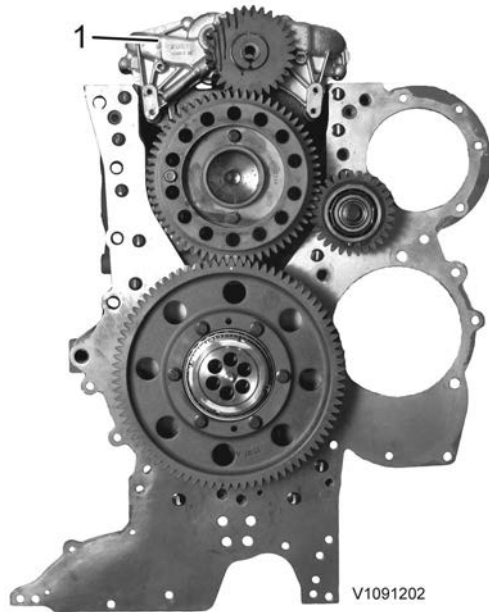
Fig.69

- 25 Install the double gear.
Use 885812 Timing tool and tighten the bolts according to specifications.
Tightening torques, see *Engine transmission, tightening torque page 7*.

NOTE!

Rotate the crankshaft gear so that the drilled markings match the figure.

- 26 Remove the guide sleeves.



V1091202

Fig.70

- 1 Engine oil pump

- 27 Rotate the engine.
Install the engine oil pump.

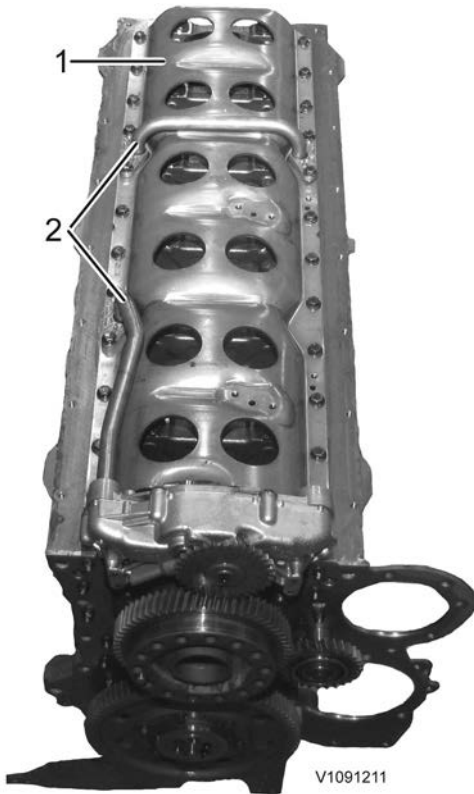


Fig.71

- 1 Ladder frame
- 2 Pipes for oil pump

- 28 Install the ladder frame and the pipes for the oil pump. Tightening torques, see *Cylinder block, tightening torques page 18*. Install 885812 Timing tool and tighten the bolts according to *Cylinder block, tightening torques page 18*.



Fig.72

- 1 Pipe with strainer

- 29 Change O-rings and install the pipe with the strainer for the oil pump.
- 30 Secure the engine by placing three axle stands under the engine.
- 31 Install the cylinder head according to *Cylinder head, fitting page 76*.

Flywheel housing

- 32 Remove the crankshaft seal.
Check that the housing is free from damage.
Apply a 1.6 mm (0.06 in) thick bead of sealant as shown in the figure.
Apply sealant around the bolt holes as shown in the figure.
Install the timing gear casing using a lifting device.
Install the bolts and tighten down according to the diagram.
Tightening torques and diagram, see *Engine transmission, tightening torque page 7*.
Weight: 70 kg (154 lbs)

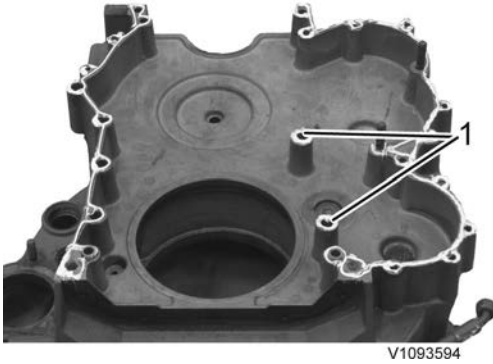


Fig.73

- 1 Sealant around bolt holes

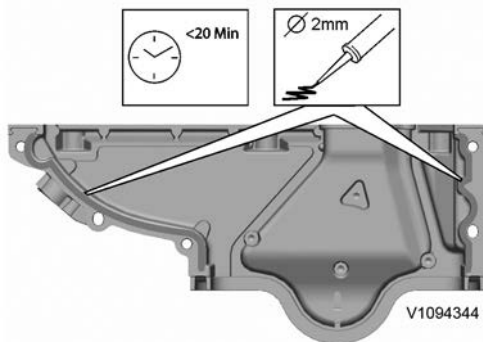


Fig.74

- 33 Apply sealant as shown in the figure.

- 34 Install the rubber seals and install the upper timing gear casing.

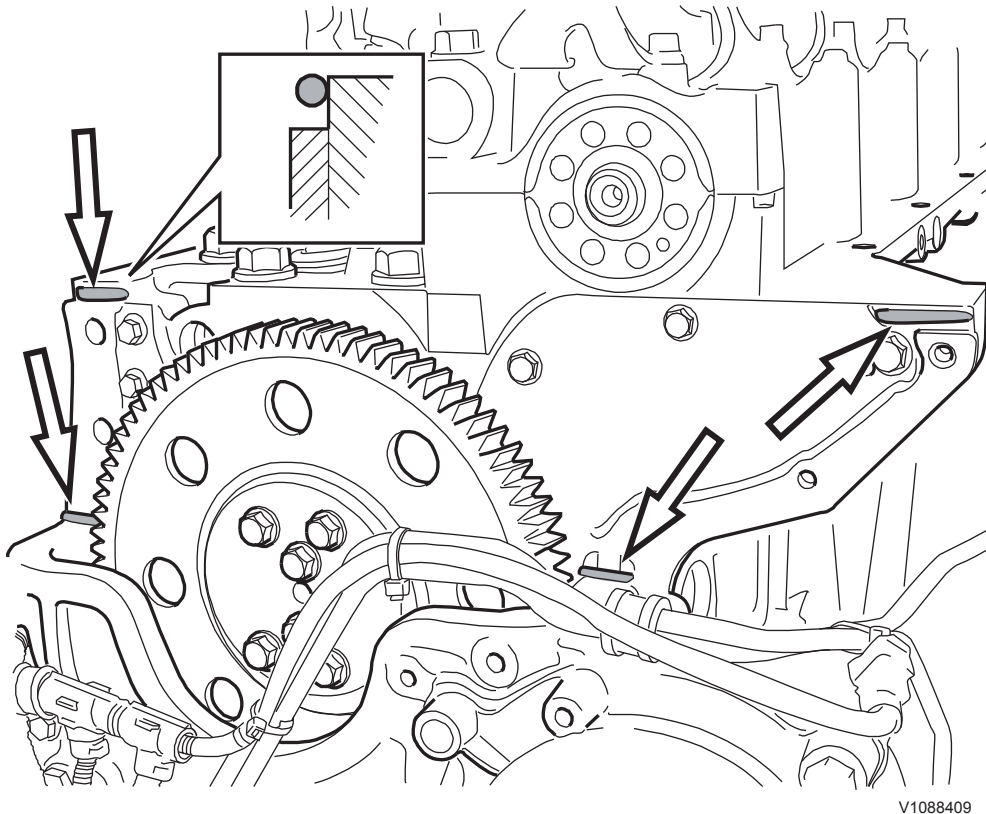


Fig.75

- 35 Install the casing with the two bolts that are located in the oval holes.

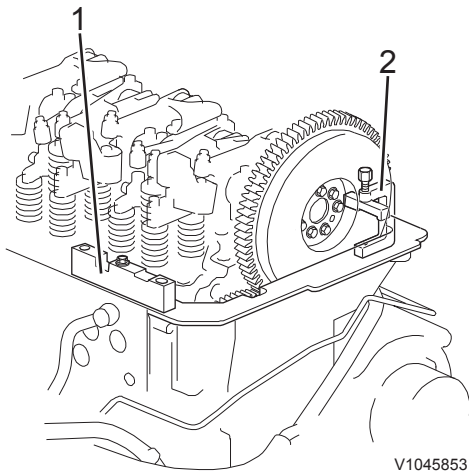


Fig.76

- 1 9998601 Installation tool
- 2 9998318 Press tool

- 36 Install 9998601 Installation tool and 9998318 Press tool. Press down the casing so that it ends up at the same height as the top of the cylinder head.

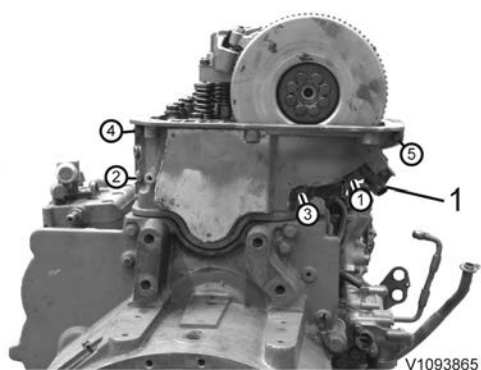


Fig.77 Upper timing gear casing

- 1 Camshaft sensor with heat shield

- 37 Install the rest of the bolts. Tighten the bolts in numerical order as shown in the figure. Tightening torques, see *Engine transmission, tightening torque page 7*
Remove the press tool.
- 38 Install the camshaft sensor and heat shield.

Crankshaft seal, rear

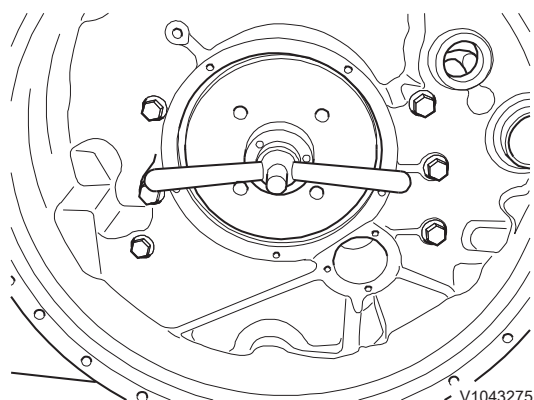


Fig.78

- 39 Clean the seal position on the crankshaft and in the casing.
- 40 Install the new seal ring on 9990166 Installation tool.
- 41 Remove the tool and check that the seal is installed correctly.

NOTE!

Check that the tool does not bottom out against the guide pin in the crankshaft.

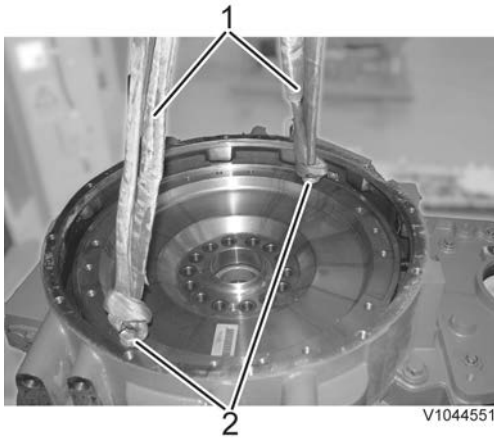


Fig.79

- 1 Sling 1 metre
- 2 M10 Lifting eye

- 42 Install the flywheel.
Install 9993590 Gear wheel.
Tighten the bolts according to the diagram.
Tightening torque: see *Flywheel, tightening torques page 26*
Weight: **WLO: 40 kg (88 lbs), EXC: 76 kg (168.55 lbs)**

NOTE!

Make sure that the flanges on the bolts are dry and clean.

Front crankshaft seal



Fig.80

- 43 Press in the crankshaft seal in the casing using 88800021 Installation tool and 9992000 Handle.
Try to install the seal so that it does not end up in the same groove as before.



Fig.81

- 44 Apply a bead of sealant on the casing as shown in the figure.
Install the casing.
Tightening torques, see *Crankshaft, tightening torques page 25*
- 45 Rotate the engine 180°.



Fig.82
1 Seal

V1093659

- 46 Scrape off surplus sealant from the crankshaft casing and the timing gear casing.
Install a new seal on the oil sump.
Install the oil sump.
Tightening torques, see *Oil sump, tightening torque page 16*
- 47 Remove the plate and the oil cooler from the coolant casing.
Pressure-test (pressurize) the oil cooler according to *Oil cooler, leakage check page 91*.
If needed, replace the oil cooler.

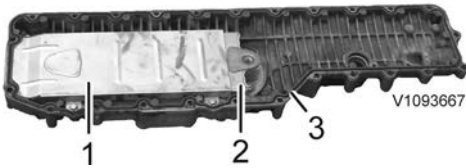


Fig.83
1 Plate
2 Oil cooler
3 Seal

V1093667

- 48 Install new seals and the oil cooler in the coolant casing.
Tighten the bolts according to the diagram.
Tightening torques, see *Oil sump, tightening torque page 16*
Install the plate.

- 49 Install a new seal on the coolant casing.
Install the coolant casing on the engine.
Tighten the bolts according to the diagram.
Tightening torques, see *Oil sump, tightening torque page 16*

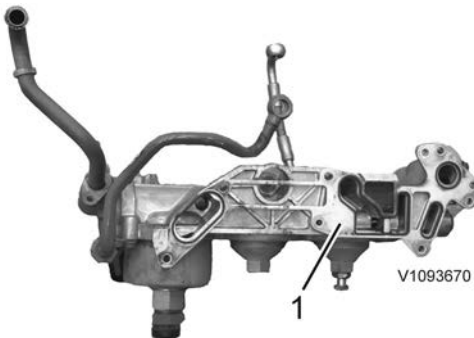


Fig.84
1 Seal, oil filter bracket

V1093670

- 50 Rotate back the engine 180°.
- 51 Install a new seal on the oil filter bracket.
Install the oil filter bracket.
Install new seals and connect the pipes.

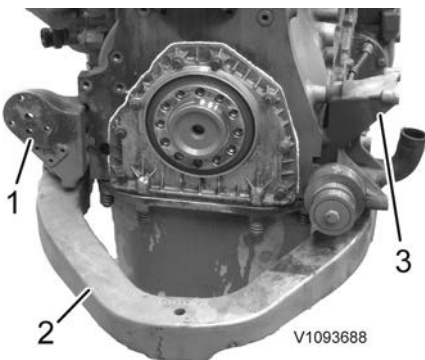


Fig.85
1 Engine mount bracket
2 Engine mount
3 Engine mount bracket

V1093688

- 52 Install the engine mount brackets on the right and left side.
Tightening torques, see *Cylinder block, tightening torques page 18*
- 53 Install the engine mount.
Tightening torques, see *Cylinder block, tightening torques page 18*

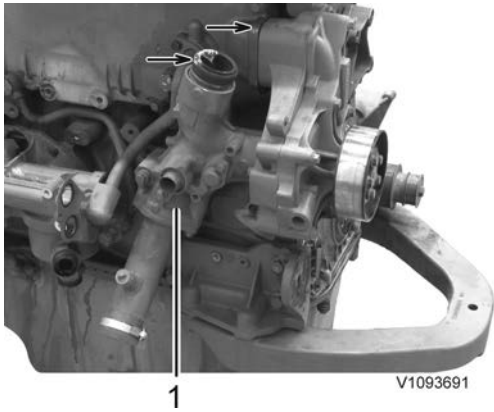


Fig.86
1 Coolant pump

- 54 Install new seals on the coolant pump.
Install the coolant pump.

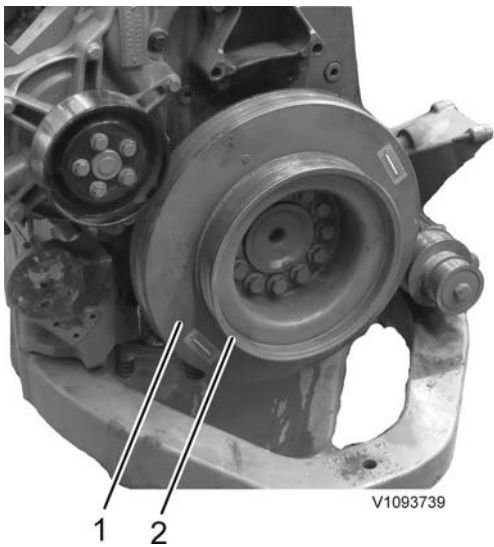


Fig.87
1 Vibration damper
2 Belt pulley

- 55 Install the vibration damper and belt pulley.
Tightening torques, see *Belt pulley/vibration damper, tightening torques page 27*
- 56 Install the upper hub centre's fan drive and the belt pulley.
For EXC — install the fan hub.
- 57 Change the seals and install the bracket for the coolant housing.
Connect the coolant pipe between the coolant pump and cylinder head.
- 58 For WLO — Install the oil filter housing.
Change the seals and connect the oil pipes.

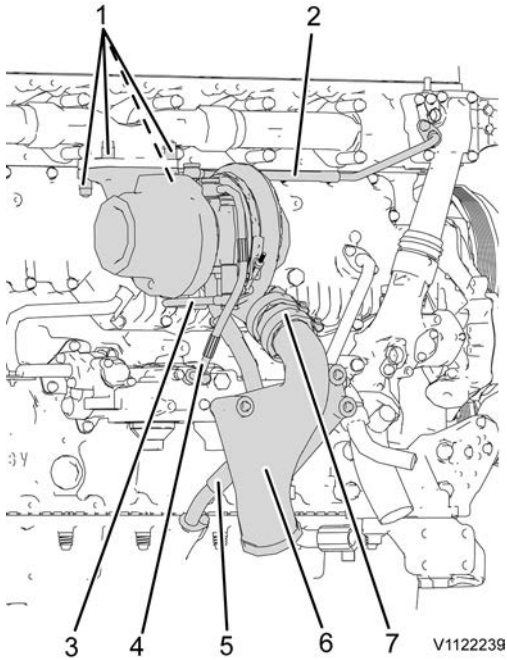


Fig.88

- 1 Bolts connecting the turbo to the exhaust manifold
- 2 Coolant line for turbo cooling
- 3 Coolant line
- 4 Oil pressure hose
- 5 Oil return hose
- 6 Charge-air cooler pipe
- 7 Clamps and hose for charge-air cooler

- 59 - Connect a lifting device to the turbo.
- Install the turbo with a new seal.
Turbo, weight: **approx. 28 kg (62 lbs)**
- Install the rear bolts for the turbo.
- Install the front bolts.
- Install the clamps and the hose for the charge-air cooler.
- Connect the oil pressure and return hoses for the turbo.
- Connect the coolant lines for turbo cooling.

Tightening torques, see *Turbocharger, tightening torques* page 21. Use 88830179 Wrench.

Speed (rpm) sensor, adjusting



Fig.89

- 60 Rotate the crankshaft with 9993590 Gear wheel so that a gear tooth on the vibration damper stands directly opposite the camshaft sensor's hole. Feel with a finger or use a mirror to check when the gear tooth is centred in the hole.

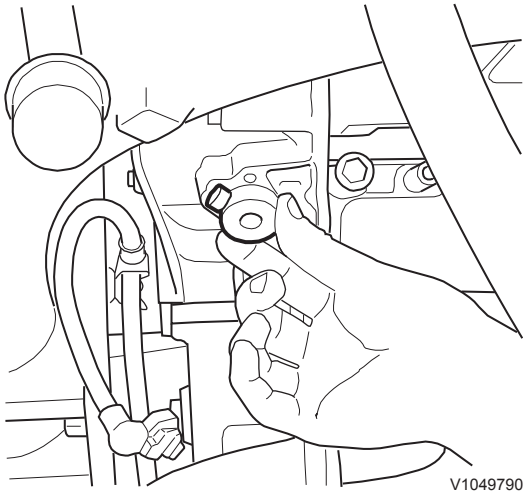


Fig.90

61 Install 88800031 Setting tool and tighten the lock bolt.

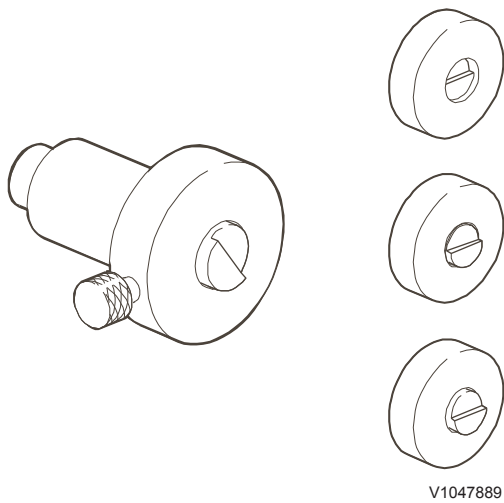


Fig.91 88800031 Setting tool

- 1 No lug outside = No spacer
- 2 One lug outside = One spacer
- 3 Two lugs outside = Two spacers

62 Check the distance to the gear teeth on the vibration damper.

63 Install a new O-ring on the sensor and lube the O-ring with vaseline. Install the new sensor with spacers as needed.

64 Repeat the same adjustment procedure for the speed (rpm) sensor on the crankshaft.

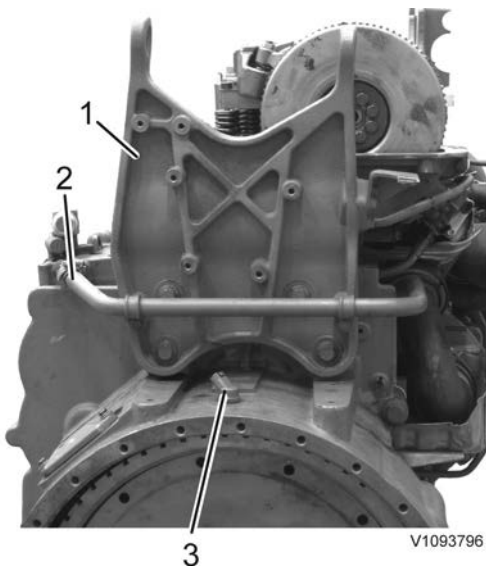


Fig.92

- 1 Lift plate
- 2 Coolant pipe
- 3 Speed (rpm) sensor

65 Install the lift plate.
Connect the coolant pipe to the coolant casing.

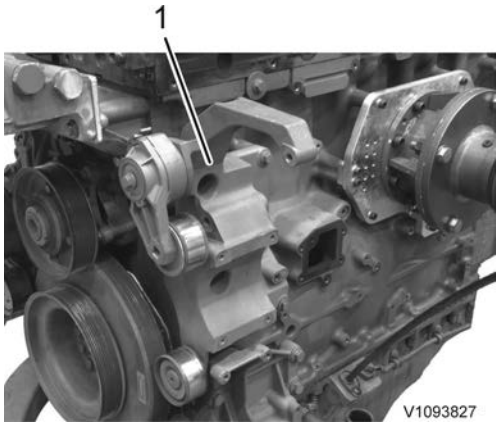


Fig.93

- 1 Bracket for AC-compressor and alternator

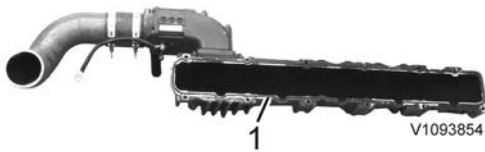


Fig.94

- 1 Seal

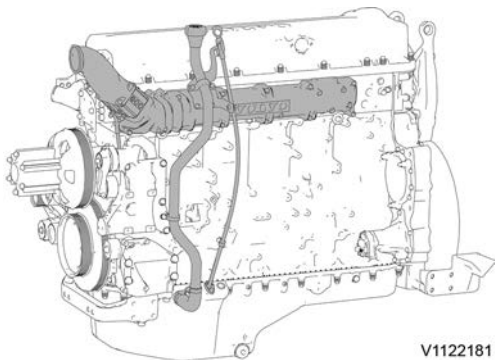


Fig.95 Inlet manifold with preheating coil, oil filler pipe, oil dipstick.

- 66 Install the bracket for the AC-compressor and the alternator.
67 Change seals and install the fuel pump.

- 68 Change seal on the inlet manifold.
Install the inlet manifold and connect to the mixing chamber.
Tightening torques, see *Cylinder block, tightening torques page 18*
69 Install the oil filler pipe and oil dipstick.

- 70 Remove the engine from the work stand according to *Engine, removing from work stand page 56*.

Engine, removing from work stand

Op. no. 210-082

Tools:

9986485 Support
88800345 Fixture
88800123 Fixture

Lifting eye, 2 pcs.
Sling 3 m (118 in)
Ratchet block 1,500 kg (3307 lbs)

NOTE!

Since the engine illustrations in the service publications are reused for different engine versions, some parts may vary from the version in question. However, the essential information in the illustrations is always correct.

Engine D13F, weight:
WLO approx. 1,330 kg (3,932 lbs)

EXC approx. 1,330 kg (3,932 lbs)

- 1 Install the ratchet block and sling on the engine and connect the engine to the lifting device.
Remove the engine from 9986485 Support.

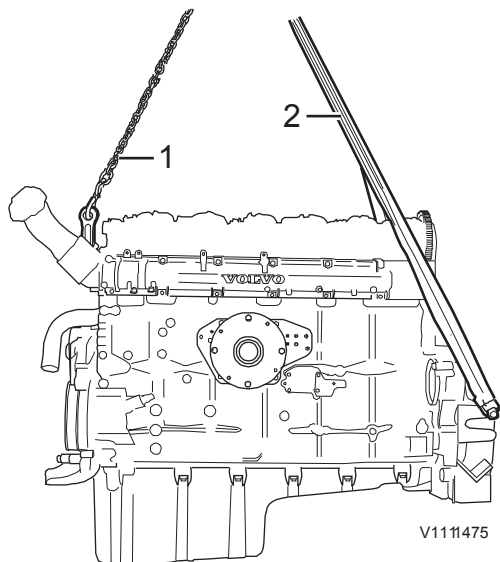


Fig.96

- 1 Ratchet block
- 2 Sling

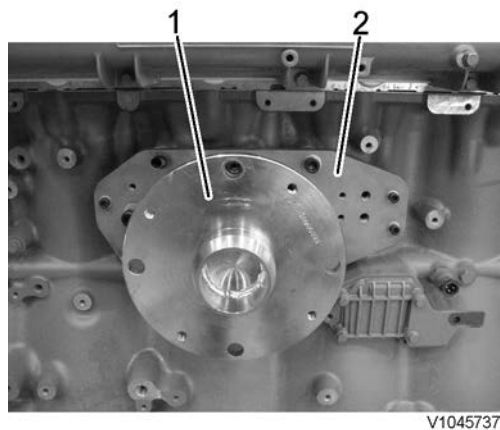


Fig.97

- 1 88800345 Fixture
- 2 88800123 Fixture

- 2 Remove 88800123 Fixture and 88800345 Fixture.
- 3 Install the E-ECU.

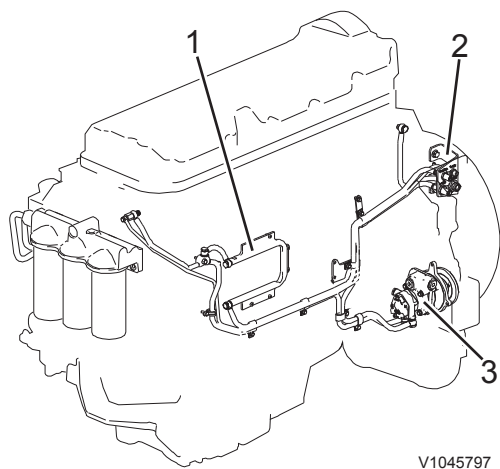
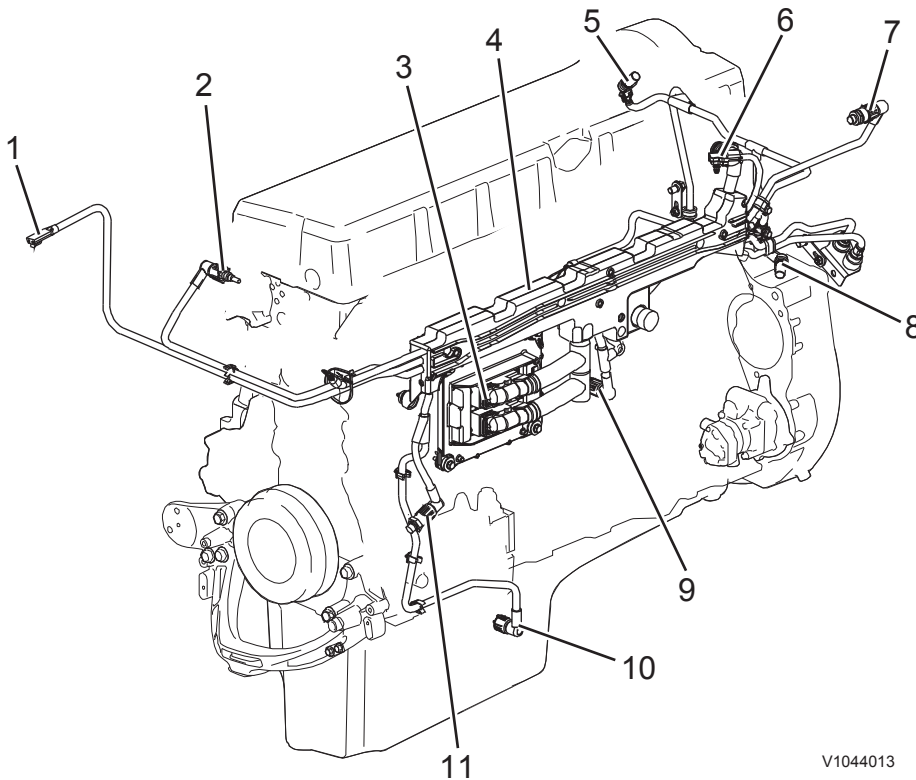


Fig.98 Fuel lines

- 1 Cooling circuit, E-ECU
- 2 Bracket — different location for EXC
- 3 Fuel pump

- 4 Install the fuel lines on the cylinder block, E-ECU, cylinder head, and the fuel pump. Install the bracket (for the fuel connections, also known as the fuel interface).

5 Install the sensors and the cable harness. Plug in the connectors for the E-ECU. Install the cable channel.

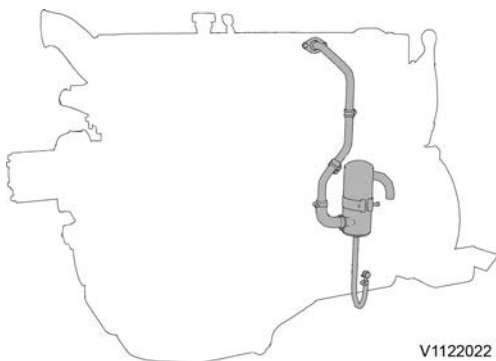


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Fig.99 Sensor, control system

- 1 Sensor for coolant level, SE2603
- 2 Sensor for coolant temperature, SE2606
- 3 E-ECU
- 4 Cable channel
- 5 Camshaft sensor, engine position, SE2703
- 6 Sensor for boost pressure/charge-air temperature, SE2507/SE2508
- 7 Sensor for air pressure/air temperature, SE2501/SE2502
- 8 Speed (rpm) sensor, flywheel, SE2701
- 9 Sensor for oil pressure, SE2203
- 10 Sensor for oil level/oil temperature, SE2205/SE2202
- 11 Sensor for crankcase pressure, SE2509

6 Install the oil trap. Connect the oil trap hose to the oil sump. Connect oil trap pipe to the valve cover.



V1122022

Fig.100 Oil trap with hose and pipe

211 Cylinder head

Cylinder head, removing

Op. no. 211-079

Tools:

88800352 Lifting tool

9993590 Gear wheel

This operation also includes tools and times necessary for applicable parts of the following actions:

- *214, Rocker arm mechanism, checking and repairing*

- 1
 - Remove the valve housing.
 - Remove the plates and the attaching bolts for the rocker arm bridge.
- 2 Check the rocker arms' clearance according to *214, Rocker arm mechanism, checking and repairing*.

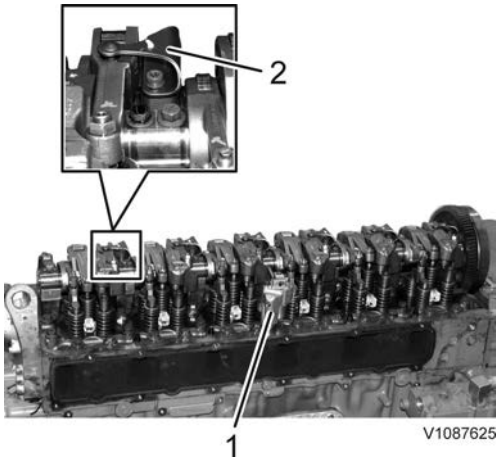


Fig.101

- 1 Valve housing
- 2 Plate

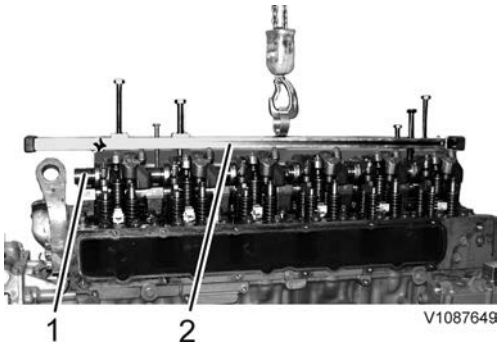


Fig.102

- 1 Rocker arm bridge
- 2 88800352 Lifting tool

- 3 Connect 88800352 Lifting tool and remove the rocker arm bridge.
Rocker arm bridge, weight: **approx. 48 kg (106 lbs)**.

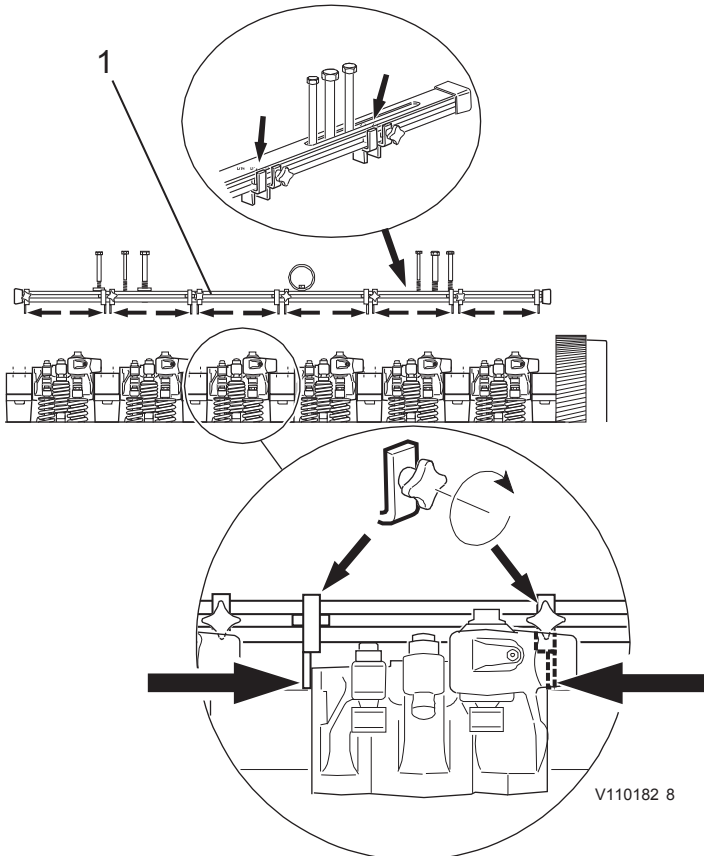


Fig.103

- 1. Lifting tool

- 4
 - Rotate the engine to reach the bolt behind the adjustable transfer gear.
 - Put some paper in place to prevent dropping bolts down in the timing gear.
 - Remove the bolts from the plate.
 - Remove the bolts from the adjustable transfer gear.

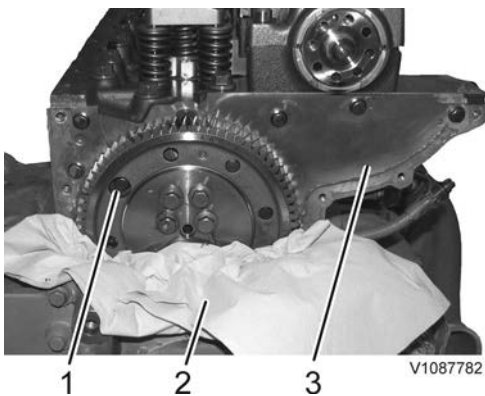


Fig.104

- 1 Bolt behind adjustable transfer gear
- 2 Paper
- 3 Plate

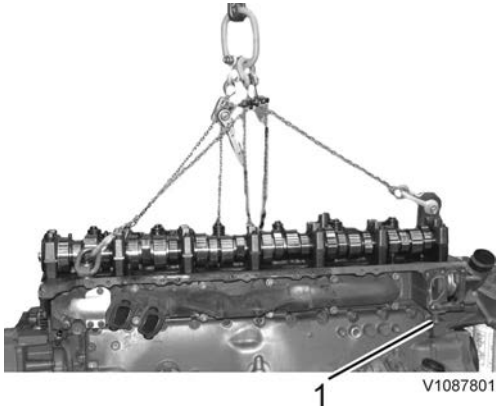


Fig.105

1 Coolant temperature sensor

- 5
- Remove all bolts for the cylinder head and remove the cylinder head.
 - Remove the coolant temperature sensor.
 - Connect a lifting device and lift away the cylinder head.
 - Place the cylinder head on wooden blocks or similar so that the injector nozzles are not crushed and damaged.

Cylinder head, weight, including camshaft and lifting device: **approx. 240 kg (530 lbs).**

Cylinder head, reconditioning

Op. no. 211-069

Tools:

11666043 Jack
88800058 Fixture
88800064 Drift
88800127 Drift
88800137 Drift
88800151 Drift
88800196 Flaring tool (copper sleeve)
88830175 Pump
88800342 Puller
9986173 Puller
9986485 Support
9990106 Sealing plate
9990107 Connection plate
9990176 Press tool
9990210 Valve spring compressor
9996239 Lifting chain
9996159 Pin
9996662 Pressure gauge
9998250 Ring
9998251 Sealing plug
9998251 Sealing plug
9998251 Sealing plug
9998251 Sealing plug
9998251 Sealing plug
9998251 Sealing plug
9998264 Lifting tool
9998266 Sealing plate
9998580 Socket
9998599 Cleaning tool
9998666 Connection plate

Dial indicator with magnetic stand
10 mm (0.39 in) drift

Installing in work stand

- 1 Install 88800058 Fixture on the cylinder head.

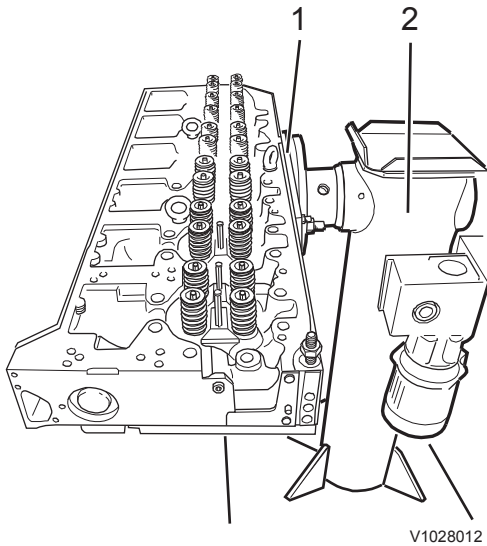


Fig.106

- 1 88800058 Fixture
- 2 9986485 Support

2

WARNING

Risk of crushing injuries

Lift up the cylinder head with 9996239 Lifting chain and secure it to 9986485 Support.
Cylinder head, weight **approx. 240 kg (530 lbs)**

NOTICE

It is important that the greatest cleanliness is exercised when working with the cylinder head.
Dirt particles in fuel and oil ducts may cause breakdown of the unit injectors.

- 3 Connect 9998264 Lifting tool to the camshaft and lift away the camshaft.
Camshaft, weight: **approx. 34 kg (75 lbs)**.
- 4 Remove the thermostat cover and the thermostat.
- 5 Remove the unit injectors.

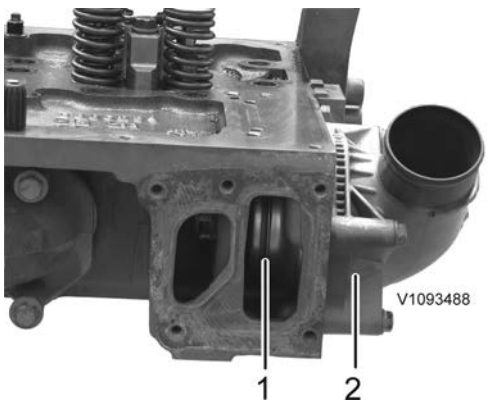


Fig.107

- 1 Thermostat
- 2 Thermostat cover

6

- Remove the manifold.
Manifold, weight: **approx. 15 kg (33 lbs)**

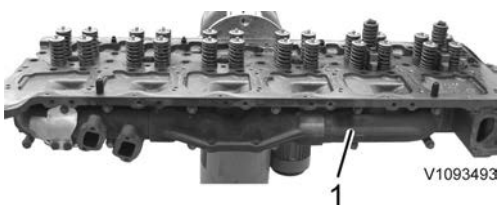


Fig.108

- 1 Manifold

Valves, removing

- 7 Remove 9998251 Sealing plug from the cylinder head.

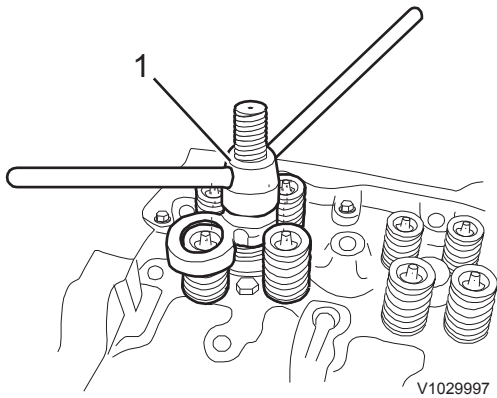


Fig.109

1 9990210 Valve spring compressor

- 8 Install 9990210 Valve spring compressor in the sleeve and fasten it in the holes for the unit injector's attaching bolts.
- 9 Press down the valve washer and remove the collets.
- 10 Remove the valve washer, springs, and valves.
- 11 Remove the rest of the valves in the same way.

NOTE!

Place the valves together with their associated springs so that they can be reinstalled in the same place in the cylinder head when assembling.

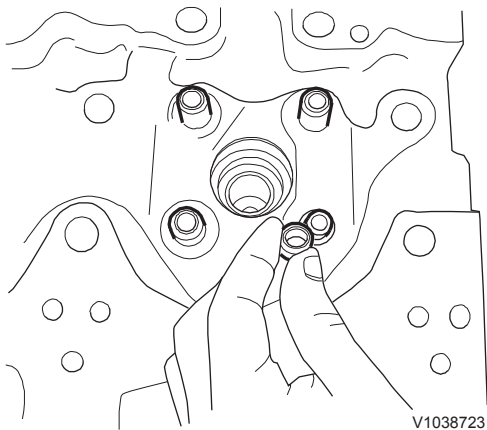


Fig.110

- 12 Remove the valve seals.

Sleeve for unit injector, removing

NOTE!

The injector sleeve must be free from soot.

There are two methods for removing the injector sleeve.

1. Tap out with drift
2. Pull out with 88800342 Puller and 9986173 Puller.

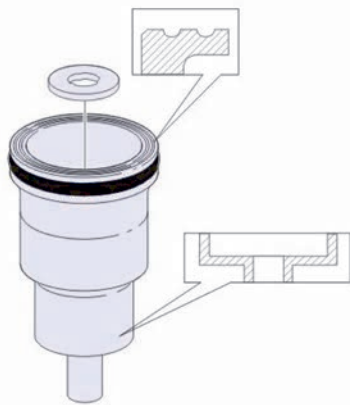


Fig.111

Sleeve for unit injector

Tap out with drift

- 13 Tap out the injector sleeve with a 10 mm (0.394 in) drift.

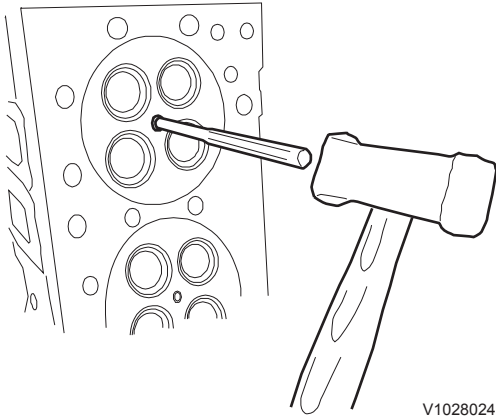


Fig.112

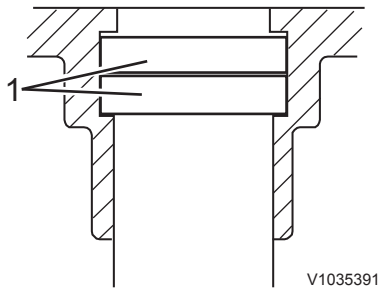


Fig.113

- 1 9998250 Ring

- 14 Install two 9998250 Ring in the cylinder head's fuel channel to protect against dirt.

Pull out with puller

- 15 Install 88800342 Puller and press down so that it bottoms out in the sleeve, a 'click' sound can be heard. On the tool there is a line marking at a depth of 66 mm. If the tool sinks down so deep that the line cannot be seen, it may be difficult to pull up the sleeve since it indicates that it has been deformed. Tighten down the tool. Tighten the expander by tightening the nut until it stops.

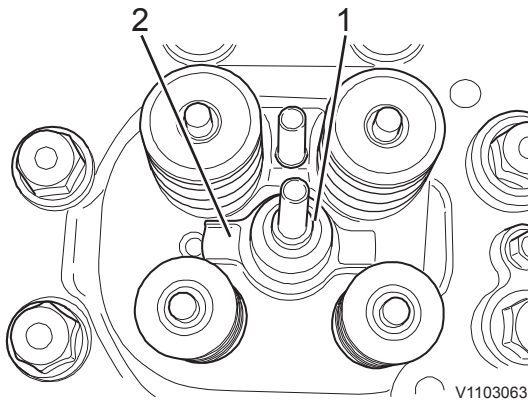
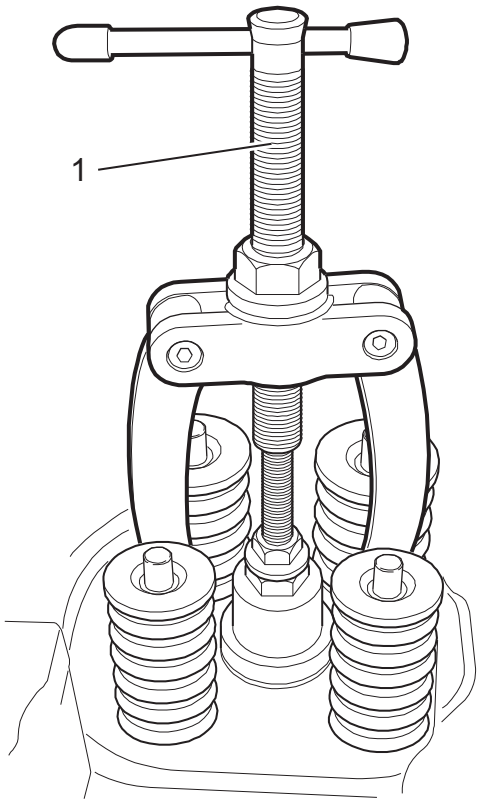


Fig.114

- 1 Puller, included in kit 88800342 Puller.
- 2 Support ring, included in kit 88800342 Puller.

16 Then install 9986173 Puller. Tighten down the puller.



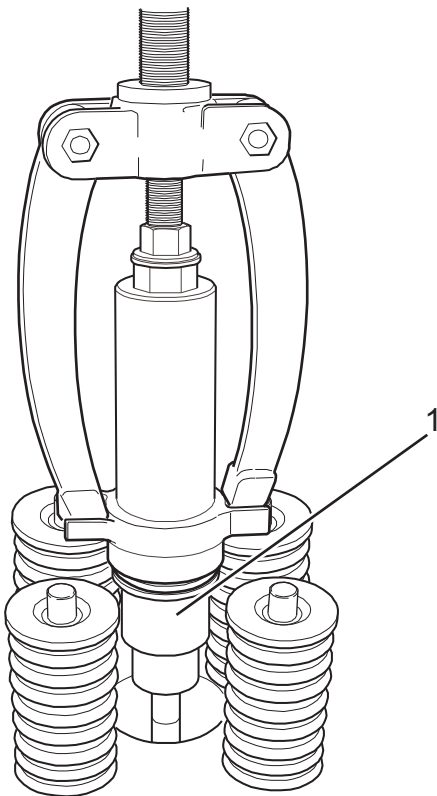
V1103064

Fig.115
1 9986173 Puller

17 Pull up the injector sleeve with the puller.

NOTE!

A deformed sleeve may be difficult to pull up. Try to remove 9986173 Puller, loosen, 88800342 Puller and try to find a new grip for the jaws. Install the counterhold and pull up the sleeve again.



V1103065

Fig.116
1 Injector sleeve

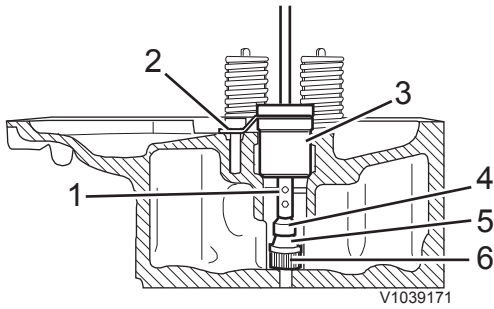


Fig.117

- 1 9808616
- 2 9808607
- 3 9998580
- 4 9808613
- 5 9808615
- 6 9808614

- 18 Remove the seal rings 9998250 Ring from the fuel channels. Clean the injector sleeve's seat in the cylinder head with cleaning kit 9998599 Cleaning tool. Use the included tools 9998580 Socket, 9808607, 9808613, 9808614, 9808615, and 9808616.

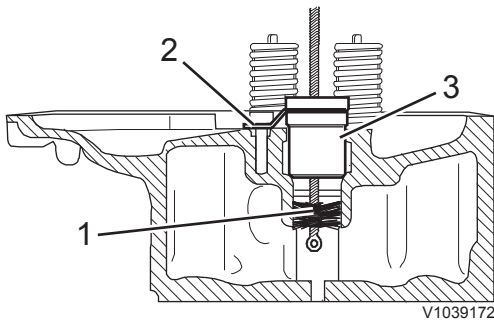


Fig.118

- 1 9808618
- 2 9808607
- 3 9998580

- 19 Clean the cylinder head's walls for the injector sleeve with 9998599 Cleaning tool. Use the included tools 9808607, 9808618, and 9998580.

NOTE!

9808607 and 9998580 shall be used to prevent dirt from entering the fuel channel.

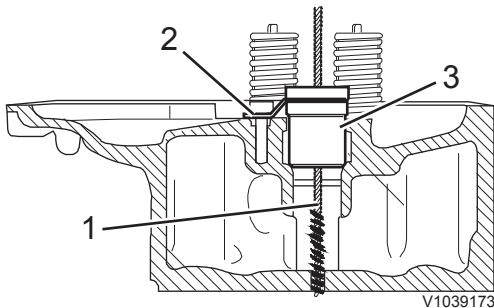


Fig.119

- 1 9808617
- 2 9808607
- 3 9998580

- 20 Clean the cylinder head's holes with 9998599 Cleaning tool. Use the included tools 9808607, 9808617, and 9998580.

NOTE!

9808607 and 9998580 shall be used to prevent dirt from entering the fuel channel.

- 21 Remove the rest of the unit injectors' injector sleeves, one at a time, in the same way.

Valve guide, checking

- 22 Turn the cylinder head with the valve seats facing up.
- 23 Place a new valve in the valve guide, so that the valve spindle's end is flush with the guide's edge.

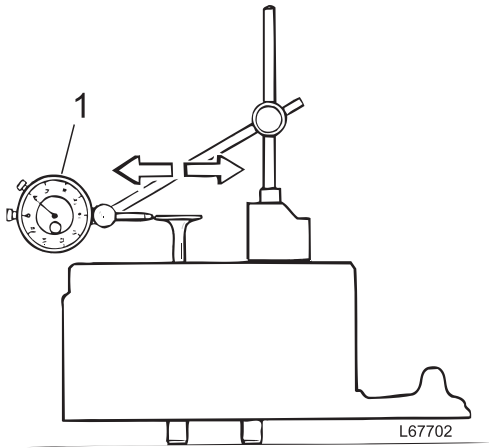


Fig.120

- 1 Dial indicator

- 24 Place the dial indicator with magnetic stand so that the dial indicator's styles has contact with the valve disc's edge. Move the valve sideways in the direction of the exhaust and inlet channels. Read off the value on the dial indicator.
- 25 Check all valve guides. If the measured values exceed the highest permitted value according to *Valve mechanism, specifications page 14* the valve guides shall be changed.

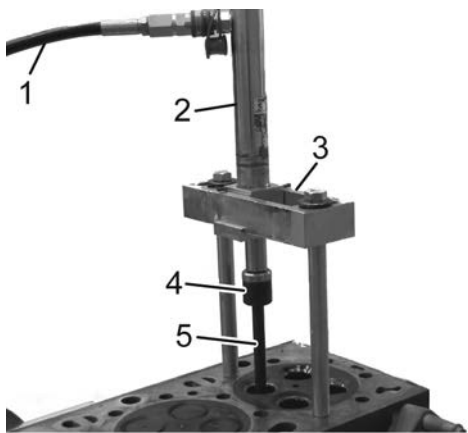


Fig.121

- 1 88830175 Pump
- 2 11666043 Jack
- 3 9990176 Press tool
- 4 9996159 Pin
- 5 88800137 Drift

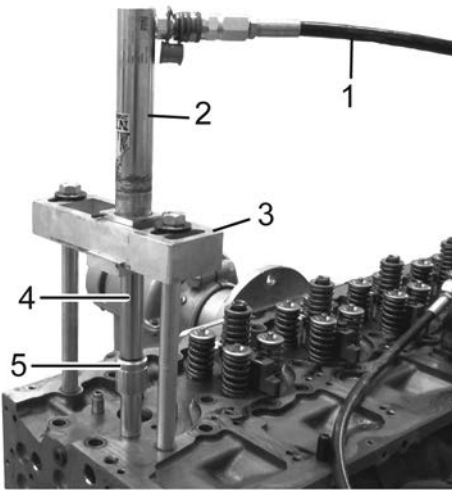
Valve guides, changing

- 26 Install 9990176 Press tool in the holes for the cylinder head's attaching bolts. Install 11666043 Jack in 9990176 Press tool and press out the valve guide using 88800137 Drift, 9996159 Pin and 88830175 Pump. Press out the rest of the valve guides in the same way.
- 27 Oil in the outside of the valve guides with engine oil before installing.

WARNING

Use safety glasses.

- 28 Press in the valve guides with 88800064 Drift (inlet valves) and 88800127 Drift (exhaust valves). Press until the tool bottoms out against the cylinder head's face. The rest of the valve guides are pressed in in the same way. After changing valve guides the cylinder head shall be cleaned to prevent particles from entering the fuel chamber or oil channels. Dirt particles can cause failure of the unit injectors.



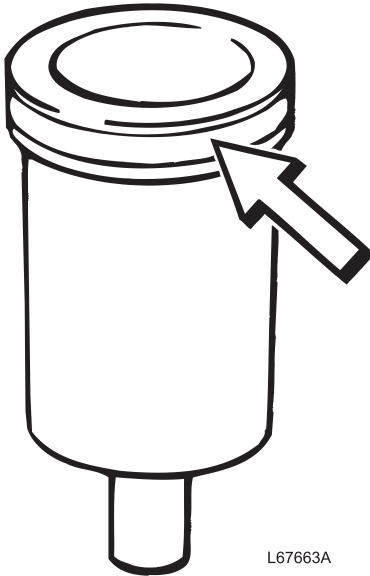
V1094651

Fig.122

- 1 88830175 Pump
- 2 11666043 Jack
- 3 9990176 Press tool
- 4 9996159 Pin
- 5 88800064 Drift (inlet valves) / 88800127 Drift (exhaust valves)

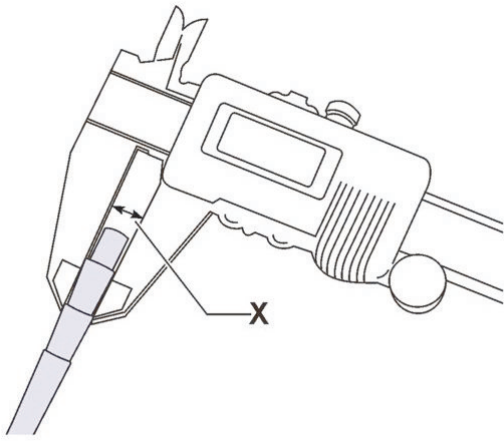
Injector sleeve, installing

- 29 **NOTE!**
Always use a new O-ring.
Lube the O-ring on the injector sleeve with soapy water.



L67663A

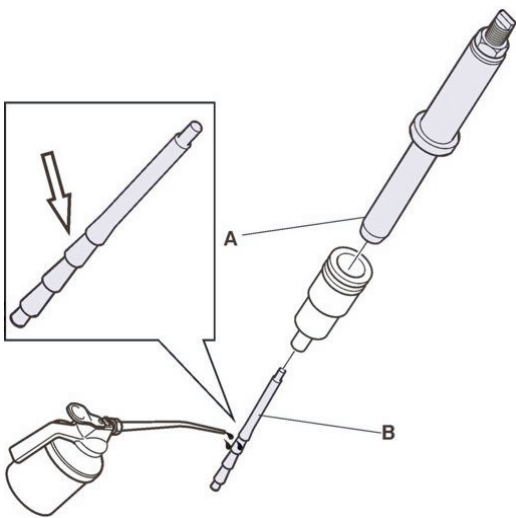
Fig.123
Sleeve



V1099411

Fig.124 Flaring pin
The measurement X shall be 7.9 ± 0.05 mm (0.311 ± 0.00197 in)

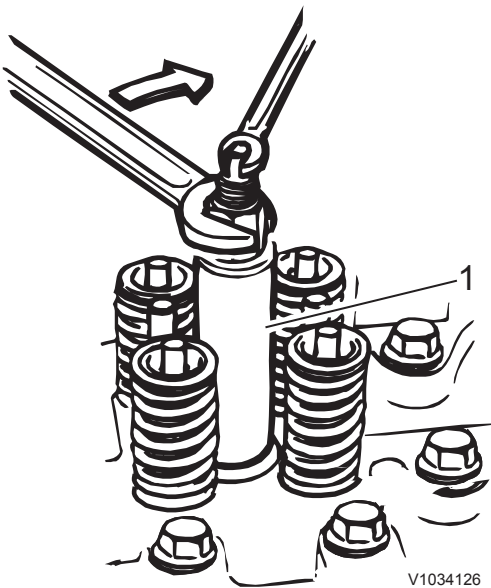
30 Check that the correct flaring pin is used. Measure the pin, see figure.



V1099397

Fig.125
A Flaring tool
B Drift pin (replaceable)

31 Place the injector sleeve on the 88800196 Flaring tool (copper sleeve) (A). Grease the threads and also grease under the nut on the tool (A). Screw in the tool (B) until it reaches the bottom of the sleeve and then turn it back up half a revolution. Oil in the pin on the tool (B).



V1034126

Fig.126
1 88800196 Flaring tool (copper sleeve)

32 Flare the injector sleeve by screwing on the nut at the same time as the spindle is held in place until the drift pin has been tightened all the way through.

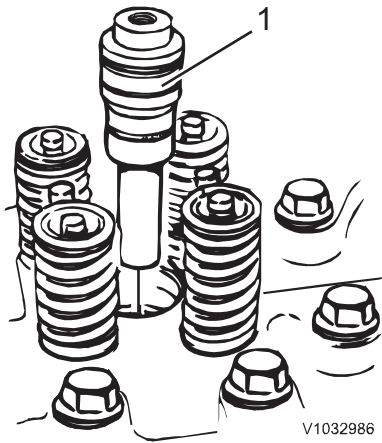


Fig.127

- 1 9998251 Sealing plug

- 33 Install the protective tool 9998251 Sealing plug in the hole for the unit injector. Fasten the tool in the hole for the unit injector's fastener yoke.

Cylinder head, checking for leaks

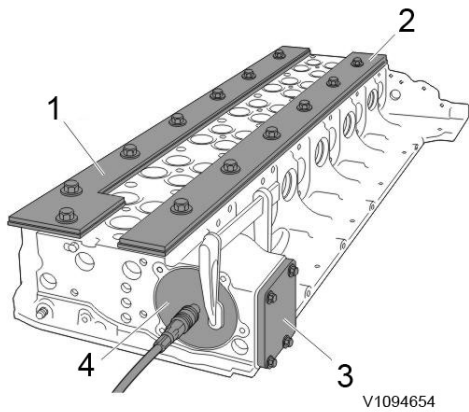


Fig.128

- 1 9998666 Connection plate
- 2 9998266 Sealing plate
- 3 9990106 Sealing plate
- 4 9990107 Connection plate

- 34 Clean the contact faces on the cylinder head.
- 35 Install:
 - The L-shaped connecting plate from the tool kit 9998666 Connection plate and 9998266 Sealing plate on the cylinder head. Use cylinder head bolts and nuts M16.
 - 9990107 Connection plate for the thermostat housing.
 - Plug M12x1.5 in the temperature sensor hole
 - 9990106 Sealing plate on the side of the cylinder head
 - 9996239 Lifting chain
- 36 Connect 9996662 Pressure gauge. Connect the hose to the connecting plate (9990107).

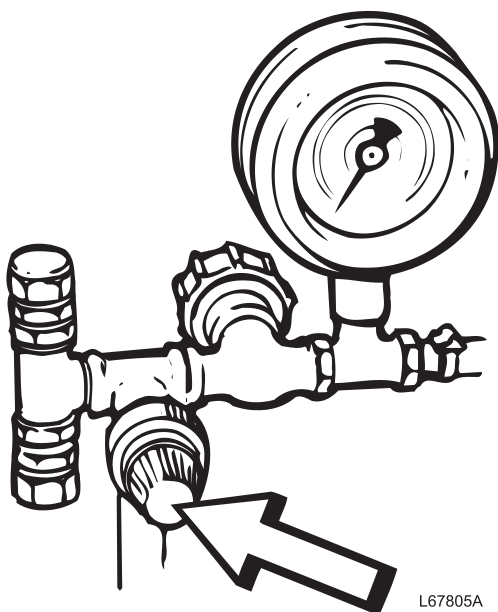
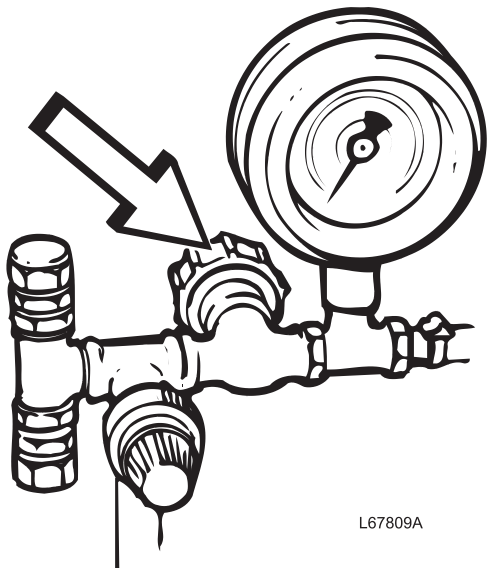


Fig.129 Reduction valve

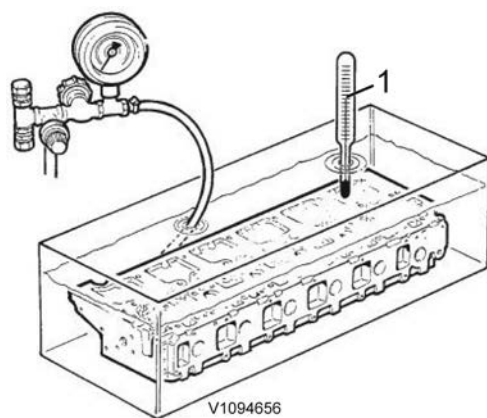
- 37 Connect the pressure gauge to the workshop's compressed air system. Adjust the pressure to **100 kPa (14.5 psi)** with the reduction valve.



L67809A

Fig.130 Shut-off valve

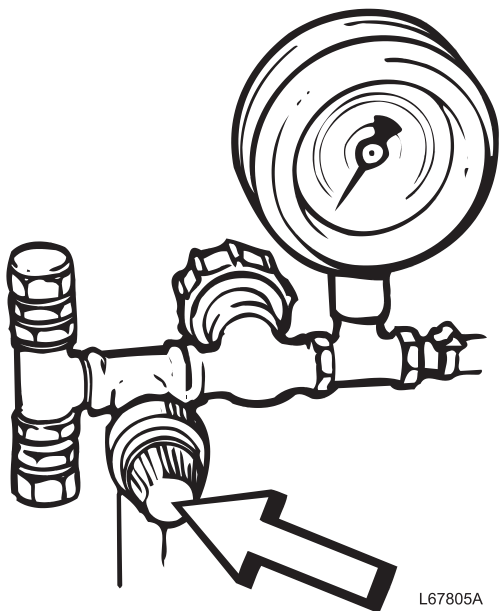
- 38 Close the shut-off valve for 2 minutes. The pressure should not drop during this time.



V1094656

Fig.131
1 70 °C (158 °F)

- 39 Immerse the cylinder head in water with the temperature **70 °C (158 °F)**.
- 40 Screw out the pressure gauge's reduction valve.
- 41 Set the reduction valve so that the pressure becomes **50 kPa (7.3 psi)**. Let that pressure act for 1 minute.



L67805A

Fig.132 Reduction valve

- 42 Increase the pressure to **150 kPa (21.8 psi)** . Lock the reduction valve's knob with the lock ring and close the valve. Check after **2 minutes**. If the pressure drops, check where the bubbles come from.
- 43 Lower the pressure in the cylinder head with the reduction valve.
- 44 Lift up the cylinder head from the water. Remove the sealing plates and the tools. Blow the water off the cylinder head.

Valve seat, checking

- 45 Check the valve seat's depth against the cylinder head. The valve seats shall be changed when distance (A) measured with a new valve exceeds the tolerance according to *Valve mechanism, specifications page 14*, otherwise clean the soot off and grind them.

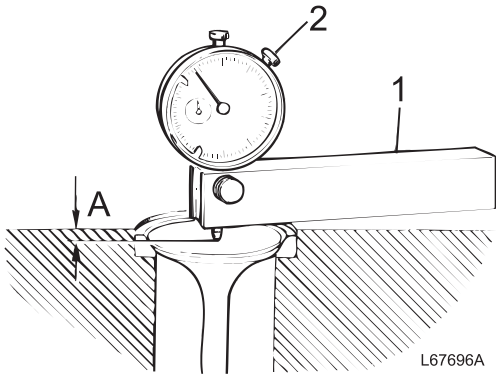


Fig.133

- 1 9992479 Retainer
2 Dial indicator

Valve seat, cleaning soot and grinding

- 46 When valve seats are ground do not remove too much material, only enough so that the valve seat has the correct shape and the valve disc has a good contact surface.
- 47 A new valve seat is ground down so that distance (A) between the cylinder head's face and the valve disc's face, measured with a new valve, is according to specifications.

Valve seat, changing

- 48 Grind down two edges on the disc of a discarded valve.

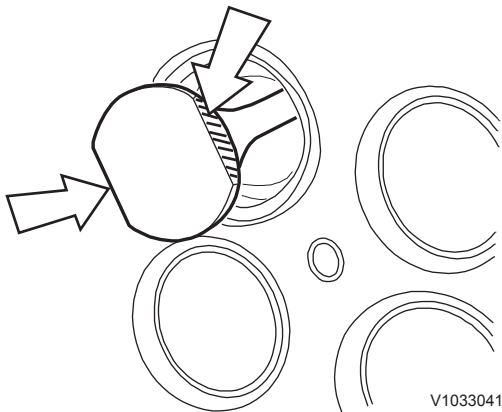


Fig.134

- 49 Weld the valve in the valve seat.

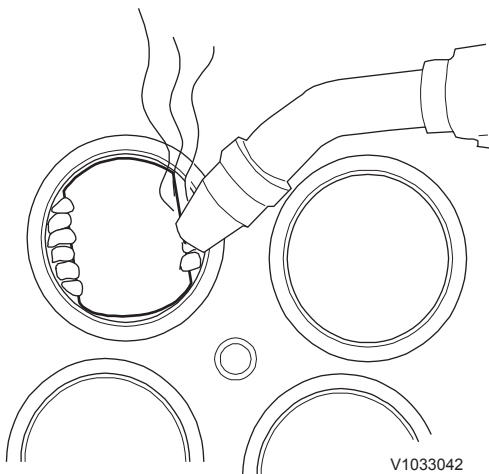


Fig.135

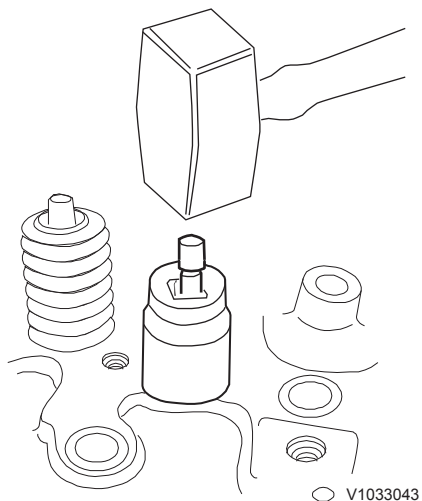


Fig.136

- 50 Place a suitable sleeve as protection over the valve/valve guide. Carefully tap out the valve and valve seat with a hammer.

NOTE!

Work carefully so that the cylinder head is not damaged.

- 51 Clean the seat's position thoroughly and check the cylinder head for cracks.

No cracks are permitted on the cylinder head.

- 52 Measure the diameter of the valve seat's position. Check if a seat of standard dimension should be used. If needed, rework the valve seat's position.

- 53 Cool the seat in dry ice to a temperature between **-60 °C and -70 °C (-76 °F and -94 °F)**.

Warm the cylinder head with a hot-air gun or in another way. Press in the valve seat with a suitable drift.

NOTE!

Risk of frostbite. Use protective gloves.

- 54 Rework the seat to correct angle and width according to *Valve mechanism, specifications page 14*.

Valves, grinding

- 55 Check the valve disc's edge thickness (A). If the measurement is less than according to *Valve mechanism, specifications page 14* the valve should be changed.

- 56 Check the valves' sealing with marking paint. In case of leakage, grind the valve seat again, but not the valve, then check again.

- 57 The sealing face should be ground as little as possible, however, enough to grind off all damage.

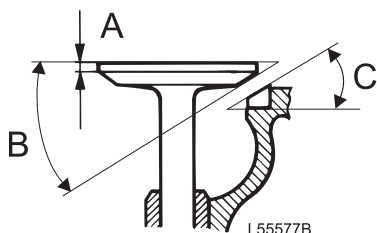


Fig.137 Inlet valve

- A Valve disc's edge thickness
- B Valve's seat angle
- C Valve seat's angle

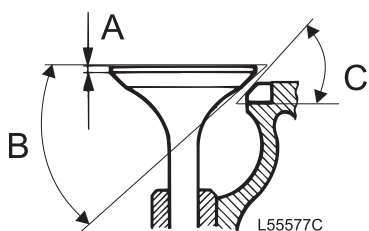
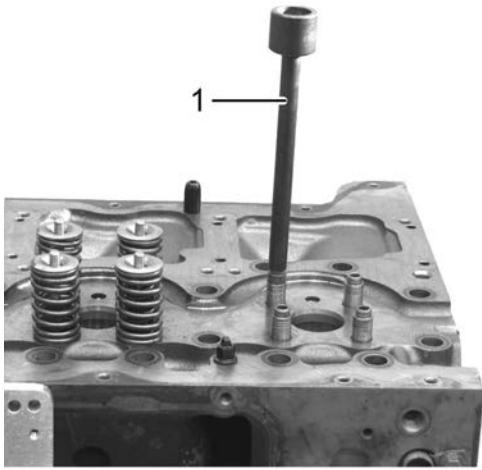


Fig.138 Exhaust valve

- A Valve disc's edge thickness
- B Valve's seat angle
- C Valve seat's angle

Cylinder head, assembling

- 58 Install the valves.



V1093486

Fig.139

- 1 88800147 Drift

59 **NOTE!**

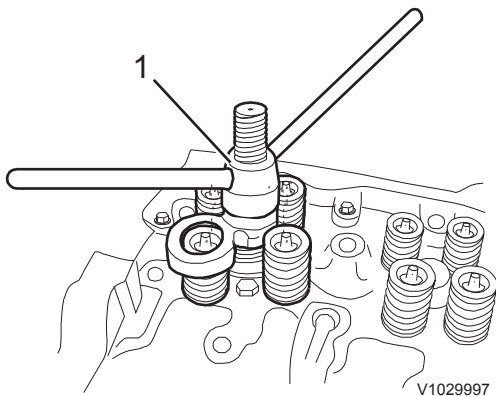
Before installing the new valve seals, thoroughly clean the valve seals' contact face with degreaser or similar.

Install the new oil seals over the valve guides with 88800151 Drift.

NOTE!

Make sure that the oil seals are pressed all the way down so that the seals' undersides seal tight against the valve guides.

- 60 Install the valve washers on the springs.
Install the springs.

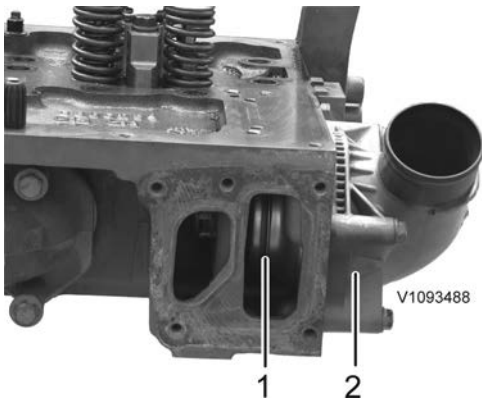


V1029997

Fig.140

- 1 9990210 Valve spring compressor

- 61 Fasten 9990210 Valve spring compressor in the hole for the unit injector's fastener yoke. Compress the valve washer and spring with 9990210 Valve spring compressor. Install the collets.



V1093488

Fig.141

- 1 Thermostat
- 2 Thermostat cover

- 62 Install the thermostat and the thermostat cover.

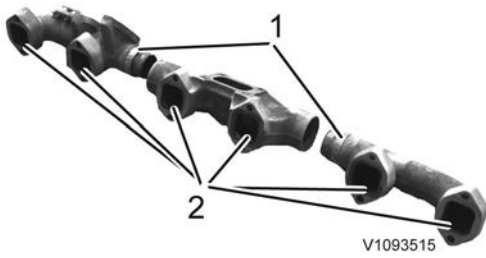


Fig.142

- 1 Seal rings
- 2 Seals



Fig.143 Unit injector with copper sleeve

- 1 Seals
- 2 Seal ring

- 63 Install the new seals and rings on the manifold.
Turn the steel side of the seals to face the manifold.
- 64 Install the manifold.
Tighten the bolts according to the diagram, see *Exhaust manifold, tightening torques page 21*.
- 65 Remove 9998251 Sealing plug.

Copper sleeve

- 66 Install new seals and seal ring on the injectors. Install the injectors.
Tightening torques, see *Tightening torque, fuel system page 21*.

! WARNING

Risk of crushing injuries

- 67 Lift away the cylinder head from the work stand with 9996239 Lifting chain.
Cylinder head, weight **approx. 240 kg (530 lbs)**

Cylinder head, fitting

Op. no. 211-081

- Tools:
- 885811 Timing tool
 - 88880003 Bracket
 - 88800352 Lifting tool
 - 9993590 Gear wheel
 - 9998264 Lifting tool

Feeler gauge

This operation also includes tools and times necessary for applicable parts of the following actions:

- *Valves, adjusting page 88*

- 1 Clean contact face and sealing faces on the cylinder block and cylinder head.
- 2 Install a new cylinder head gasket and align with the cylinder liners. Install the bolts with washers that work as guides for the cylinder head.

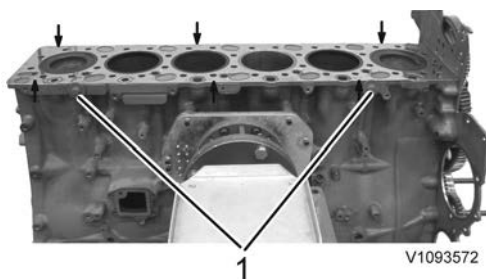


Fig.144

- 1 Guides for cylinder head

- 3 Immerse the entire length of the cylinder head's bolts in rustproofing agent.

NOTE!

The component must be installed within 20 minutes of applying sealant.

- 4 Apply sealant outside of the timing gear plate's groove.



Fig.145

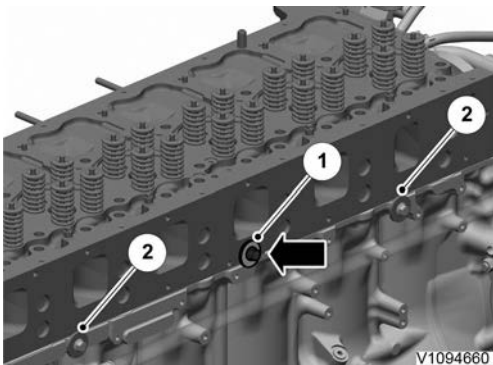


Fig.146

- 5 Loosen the bolts (2) with washer to get extra space for the cylinder head.
Connect a lifting device and lower the cylinder head.
Cylinder head, weight **approx. 240 kg (530 lbs)**.
Make sure that the washer ends up outside of the engine block's edge. Then tighten the bolt (1) so that the washer pulls the cylinder head sideways until it contacts the two washers located on the side of the block. Tighten the bolts (2) a revolution or two.

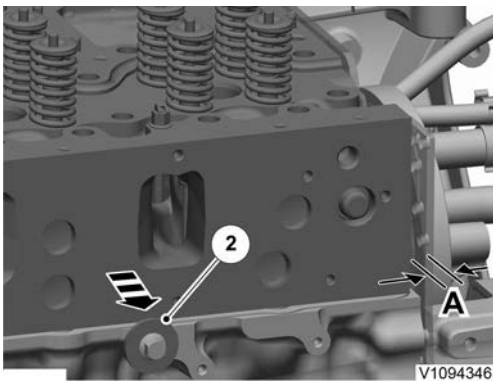
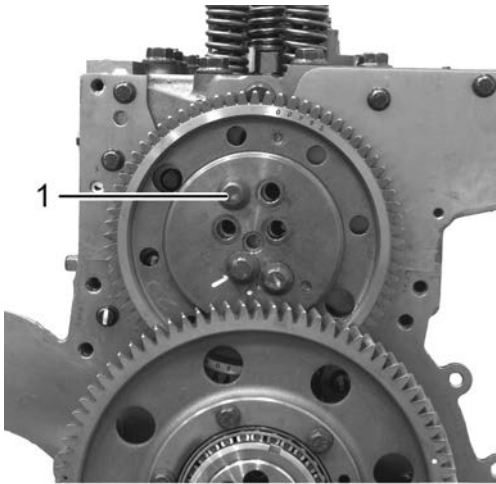


Fig.147

A 5–10 mm (0.2–0.4 in)

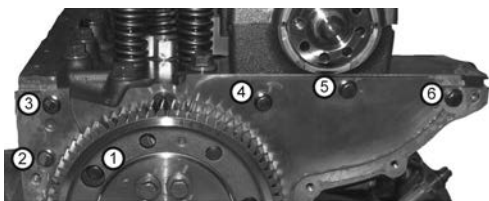
- 6 Leave a distance of 5–10 mm (0.2–0.4 in) to the timing gear plate.



V1093580

Fig.148
1 Bolt

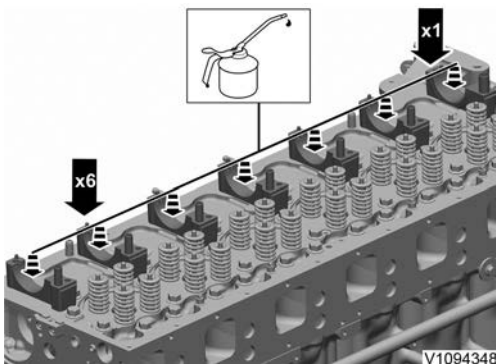
- 7 Install a bolt in the upper timing gear and tighten it so that the cylinder head is pulled against the timing gear plate. Loosen the bolt approx. one revolution. Now the cylinder head is in the correct position to be tightened down with the cylinder head bolts.
- 8 Install the cylinder head bolts. Use 885811 Timing tool when tightening. Tightening torques, see *Tightening torque, cylinder head page 6*



V1093885

Fig.149

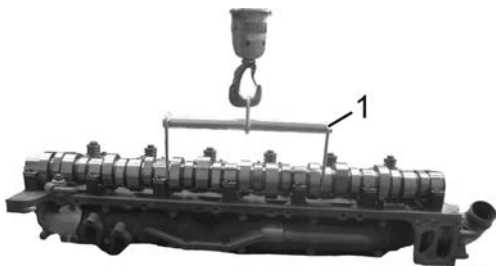
- 9 Install the bolts for the timing gear plate. Rotate the timing gear so that the bolt behind the upper timing gear can be reached. Tighten all bolts for the timing gear plate in numerical order. Tightening torques, see *Cylinder block, tightening torques page 18*.



V1094348

Fig.150

- 10 Install the camshaft's bearing brackets according to marking on the cylinder head. Make sure that they have contact with the cylinder head. Place the bearing shells in the bearing brackets. Lube with lubrication oil in the bearing shells.



V1091226

Fig.151
1 9998264 Lifting tool

- 11 Place the camshaft in the bearing shells using 9998264 Lifting tool.
Weight: 34 kg (75 lbs)

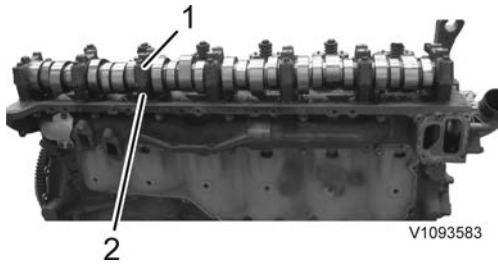


Fig.152

- 1 Bearing caps with bearing shells
- 2 Bearing brackets with bearing shells

- 12 Oil in the bearing shells and install the bearing caps on each bearing bracket according to marking.

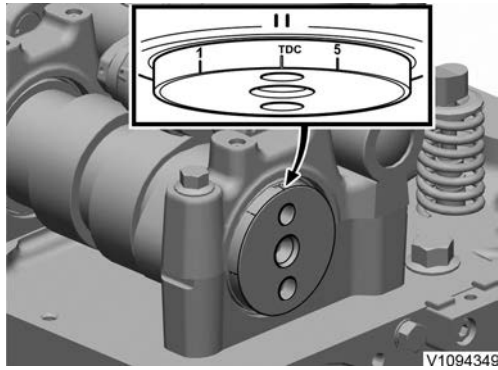


Fig.153 Camshaft marking

- 13 Rotate the camshaft to TDC.

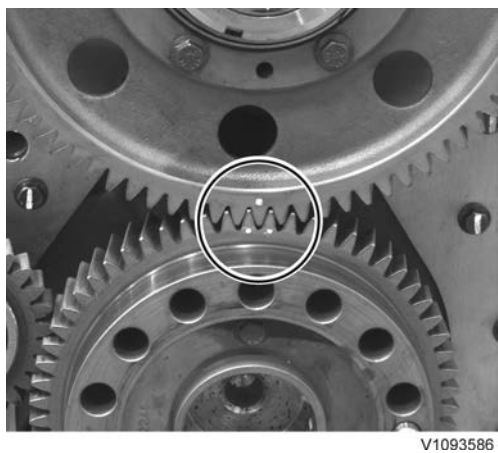


Fig.154

- 14 Rotate the timing gear so that the marking on the double gear and crankshaft gear match as shown in the figure.

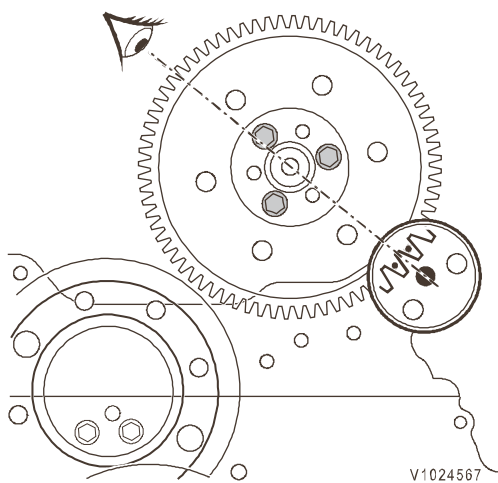


Fig.155

- 15 Install the camshaft gear so that the guide pin aligns with the hole in the camshaft and the gear's marking against the hole in the timing gear plate.

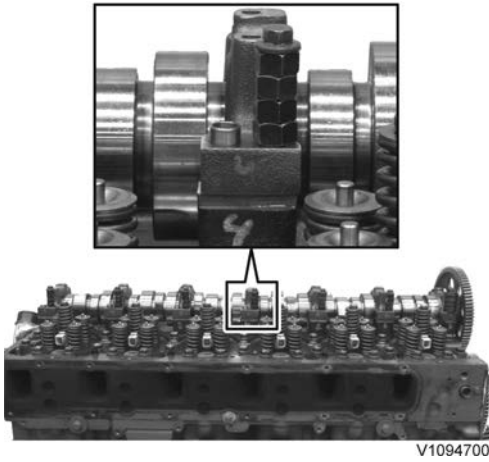


Fig.156

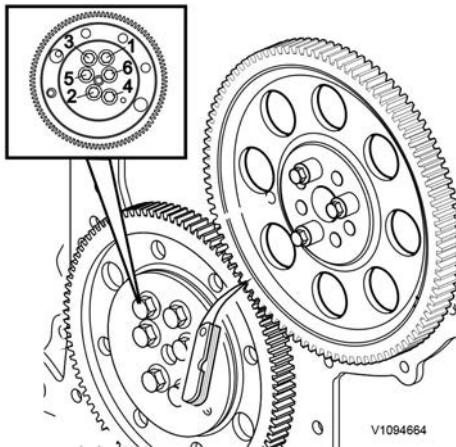


Fig.157

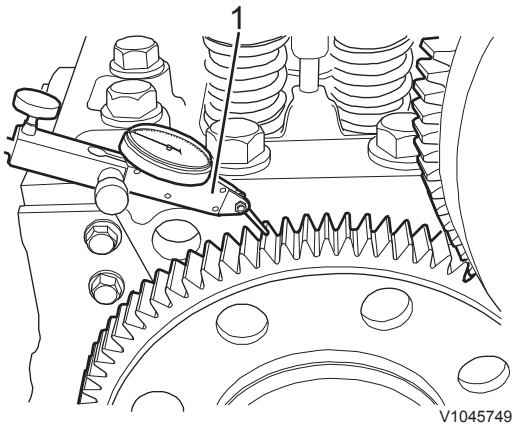


Fig.158

1 Rocker indicator

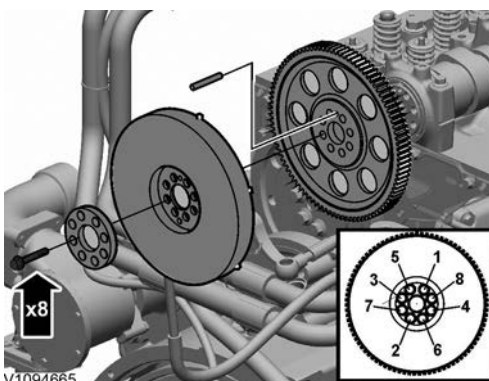
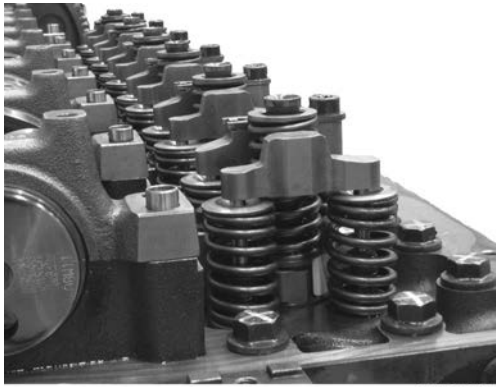


Fig.159

- 16 Install spacers on the bolts for the camshaft gear and torque-tighten temporarily with **approx. 50 Nm (37 lbf ft)**. Install spacers **approx. 40 mm (1.6 in)** on the bolts for the bearing brackets to fixate the camshaft. Torque-tighten the bolts temporarily with **approx. 60 Nm (44 lbf ft)**. Check that the camshaft can be rotated while tightening.

- 17 Loosen the bolts for the upper transfer gear so that it can be moved. Check by turning the camshaft gear back and forth. When the camshaft gear is turned clockwise until it stops the transfer gear is moved to the left so that a big backlash (gear flank clearance) is obtained between the camshaft gear and the transfer gear. When the camshaft gear is turned counter-clockwise until it stops the transfer gear is moved to the right so that no backlash (gear flank clearance) is obtained between the camshaft gear and the transfer gear. Insert a feeler gauge 0.10 mm (0.0039 in) between the gears and turn the camshaft gear counter-clockwise until it stops. Then tighten down the upper transfer gear's bolts as shown in the figure, then remove the feeler gauge. Tightening torques, see *Engine transmission, tightening torque page 7*.
- 18 Check the backlash with a rocker indicator. Hold the transfer gear in place and turn the camshaft gear back and forth, then compare the result with the specification for backlash. See *Engine transmission, specification page 12*.
- 19 Remove the bolts and the spacers from the camshaft gear.

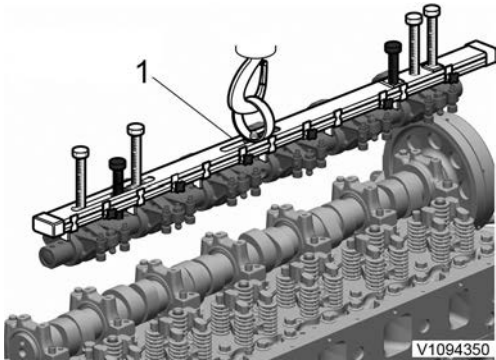
- 20 Install the vibration damper, washer, and the bolts. Tighten the bolts in the order shown in the figure. Tightening torques, see *Belt pulley/vibration damper, tightening torques page 27*.



V1093588

Fig.160

- 21 Install the valve yokes according to marking.
The oblong groove shall be turned to face the inlet side.
- 22 Lube the valve yokes and the unit injector's ball sockets.

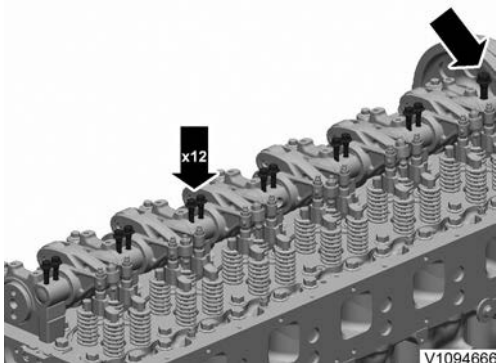


V1094350

Fig.161

- 1 88800352 Lifting tool

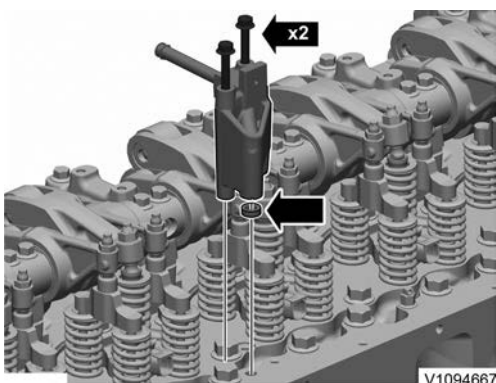
- 23 Install the rocker arm bridge using 88800352 Lifting tool and 88880003 Bracket. Guide all rocker arms so that they end up in the correct position.
Rocker arm bridge, weight **approx. 50 kg (110 lbs)**.
Remove the lifting tool from the rocker arm bridge.



V1094666

Fig.162

- 24 Install the rocker arm shaft's bolts.
Check that the valve yokes are in correct position on the valve stems.
Tighten the bolts according to the diagram in the specifications so that the rocker arm shaft does not bend.
Make sure that the shaft is guided in the guide sleeves on the bearing caps.
Tighten down the rocker arm shaft.
Tightening torques, see *Rocker arm shaft, tightening torques page 13*.



V1094667

Fig.163

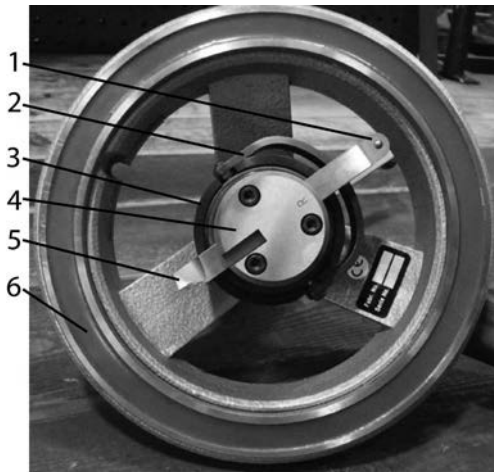
- 25 Install the valve housing and the oil pipe for the rocker arm lubrication.
- 26 Adjust the valves and unit injectors according to *Valves, adjusting page 88*.

212 Cylinder block with crankcase ventilation

Cylinder block, liners removed, milling of all liner locations

Op. no. 212-007

Tools:
9812524 Milling tool



V1092147

Fig.164

1. Centring roller
2. Lock device
3. Horizontal feed ring
4. Spindle
5. Cutter
6. Electromagnet



V1092146

Fig.165

7. Vertical feed sleeve
8. Lock bolt
9. Allen head bolt, lock

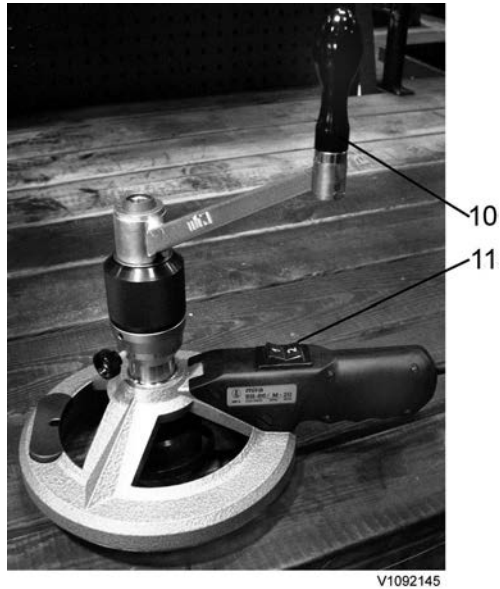


Fig.166
10. Crank
11. Switch

- 1 Hold up the lock rod and install the cutting tool. The serrated edge shall face the electromagnet and the centring roller on the side of the spindle marked R.
- 2 Place 9812524 Milling tool so that it is slightly displaced in relation to the middle of the cylinder.

NOTE!

When milling with 110 V outlet, use 88890113 Milling tool instead.

- 3 Set the switch to position 1 to activate the electromagnet.
- 4 Screw the vertical feed sleeve upwards so that the cutter can pass freely over the liner shelf.



Fig.167



V1092175

Fig.168 Centring roller

- 5 Press down the lock clamp and place the centring roller against the liner seat's wall, where the distance to the wall is the longest.
- 6 Lock the lock clamp and set the switch between position 1 and 2.



V1092150

Fig.169

- 7 Centre the tool by turning the crank clockwise while holding the horizontal feed ring in place.
- 8 The centring roller shall always have contact with the liner position's wall.
If the tool loses contact with the wall:
Turn the crank backwards (counter-clockwise) while holding the horizontal feed ring in place.
- 9 The tool is centred when it stops moving.
- 10 Then set the switch to position 1.
- 11 Press down the lock clamp.



V1092151

Fig.170

- 12 Move the cutter so that it passes over the liner shelf without touching the liner wall.



V1092148

Fig.171

- 13 Turn the crank and the vertical feed sleeve until the cutting tool comes into contact with the liner shelf.



V1092327

Fig.172

- 14 Reset the scale ring to zero and read off on the scale.



V1092152

Fig.173

- 15 Press down the lock clamp and move the cutter so that the edge ends up just inside the edge on the liner shelf (the inside diameter).

NOTE!

Set the scale ring to max. 0.05 mm (0.002 in) for the first reworking to check that the cutter mills evenly all the way around the whole cylinder.

Then rework the cylinder with max. 0.15 mm (0.006 in) per reworking.



V1092157

Fig.174

- 16 Turn the vertical feed sleeve so that the cutter starts to work against the liner shelf.



V1092150

Fig.175

- 17 Rework the liner shelf by turning the crank clockwise while holding the horizontal feed ring in place.

NOTE!

To avoid collection of dwarf and chips, release the feed ring and let the cutter rotate without feed every fifth revolution.

NOTE!

Turn the crank carefully and let the ring slide a little between your fingers when the cutting tool approaches the liner shelf's wall so that you can stop exactly when the cutting tool reaches the wall.

- 18 Repeat the process until the desired result is obtained.
- 19 Loosen the electromagnet by setting the switch to position 2 and remove the tool.
- 20 Check the depth with a dial indicator, set for each cylinder.

214 Valve mechanism

Valves, adjusting

Op. no. 214-012

Tools:
9993590 Gear wheel

Feeler gauge

- 1 Remove the protective cover on the flywheel housing and install 9993590 Gear wheel and a ratchet handle.

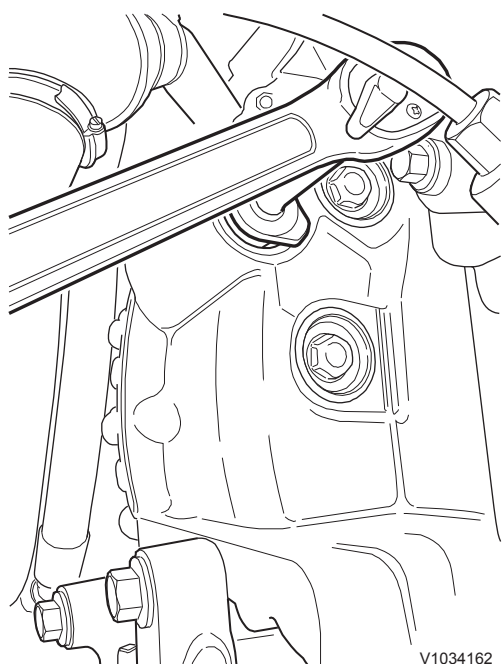


Fig.176

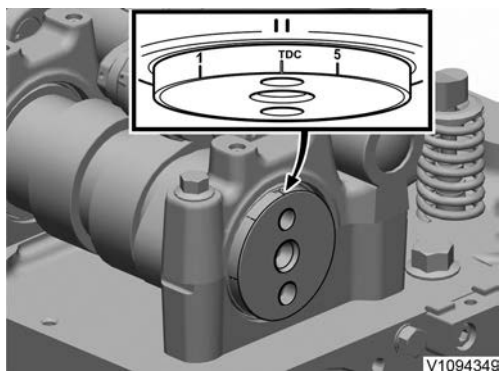


Fig.177 Camshaft marking

- 2 Rotate the flywheel with 9993590 Gear wheel until the nearest line marking on the camshaft stands between the marks on the bearing cap.

NOTE!

For WLO and EXC: Markings 1 — 6 are for adjusting inlet valves, exhaust valves, and unit injectors.

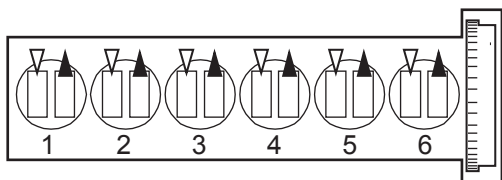


Fig.178 Cylinder number

Inlet valves, checking and adjusting

- 3 Check that the valve clearance between the yoke and rocker arm's thrust sleeve is according to *Valve mechanism, specifications page 14*. If needed, adjust as follows: Adjust correct valve clearance for the inlet valves. Place a tool in adjusting screw B as counterhold and tighten lock nut A with a box-end wrench. See *Valve mechanism, specifications page 14*. Recheck the valve clearance.

NOTE!

Using a marking pen, mark when adjusting is done to keep track of which valves, unit injectors, and brake rocker arms have been adjusted.

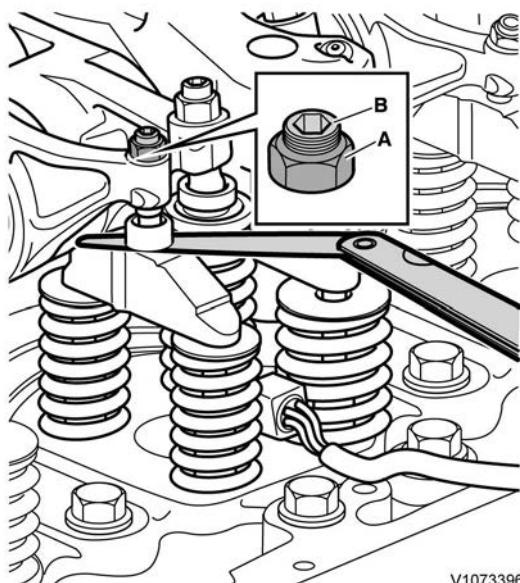


Fig.179

Unit injectors, adjusting

NOTE!

The unit injectors should only be adjusted if work has been done that involved removal of the rocker arm shaft.

- 4 Loosen the adjusting screw and adjust the rocker lever for the unit injector to zero clearance against the camshaft.
- 5 Preload the unit injector by tightening the adjusting screw according to *Tightening torque, fuel system page 21*. Then tighten the unit injector's lock bolt according to the same specification.

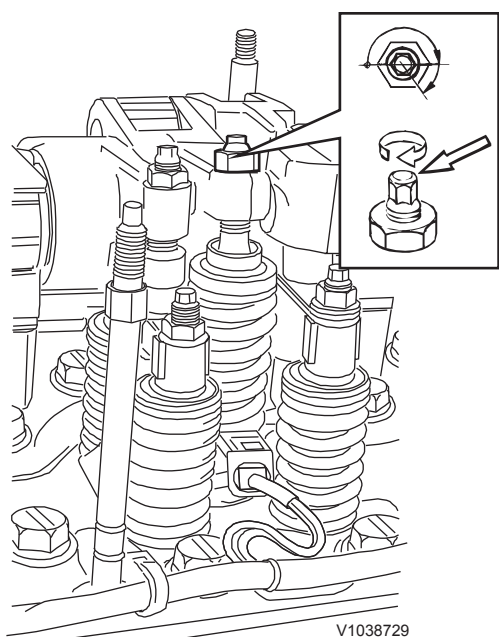


Fig.180

Exhaust valves, checking and adjusting

- 6 Check the valve clearance according to *Valve mechanism, specifications page 14*.
- 7 If the valve clearance needs to be adjusted, loosen the lock nut on the rocker arm and adjust the valve clearance with the adjusting screw according to *Valve mechanism, specifications page 14*. Then tighten the lock nut according to *Valve mechanism, tightening torques page 16*

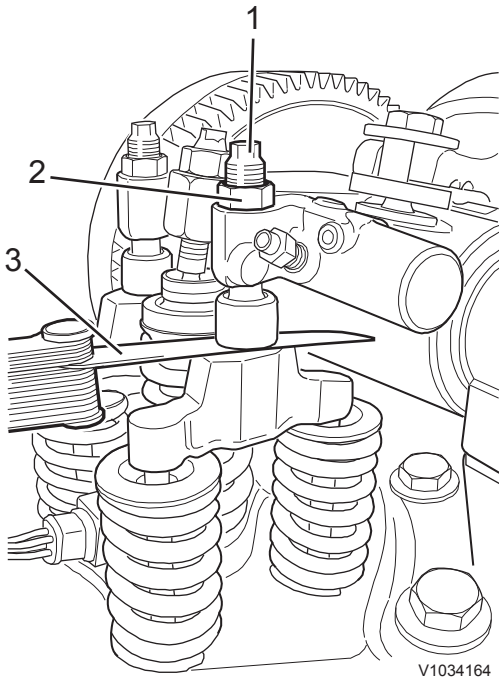


Fig.181

- 1 Adjusting screw
- 2 Lock nut
- 3 Feeler gauge

22 LUBRICATING SYSTEM

223 Oil cooler

Oil cooler, leakage check

Op. no. 223-007

Tools:

9996662 Pressure gauge

9992663 Sealing plate

9996684 Sealing plate

To detect minor leaks, the oil cooler must have the same temperature as the test room. Therefore, flush the oil cooler with water at room temperature until the oil cooler is at room temperature.

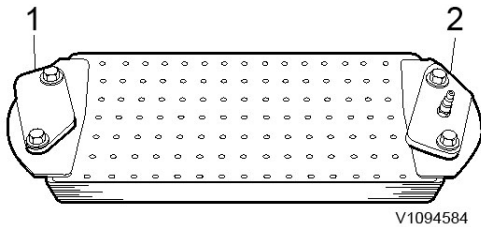


Fig.182

- 1 9992663 Sealing plate
- 2 9996684 Sealing plate

- 1 Install the pressure test equipment and check that the washers seal tight.

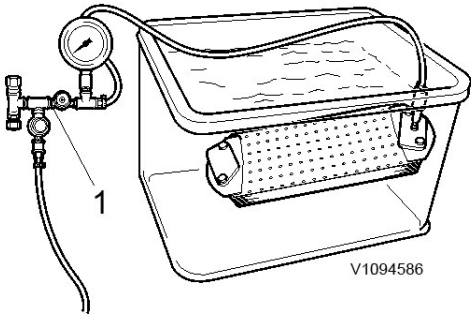


Fig.183

- 1 9996662 Pressure gauge

- 2 Connect 9996662 Pressure gauge to the oil cooler. Immerse the oil cooler in a container with water at room temperature. Gradually increase the pressure to 250 kPa. Keep that pressure for at least one minute.
- 3 Lift up the oil cooler and remove the pressure test equipment.



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A series of 20 horizontal dotted lines spanning the width of the page, providing a guide for handwriting practice.